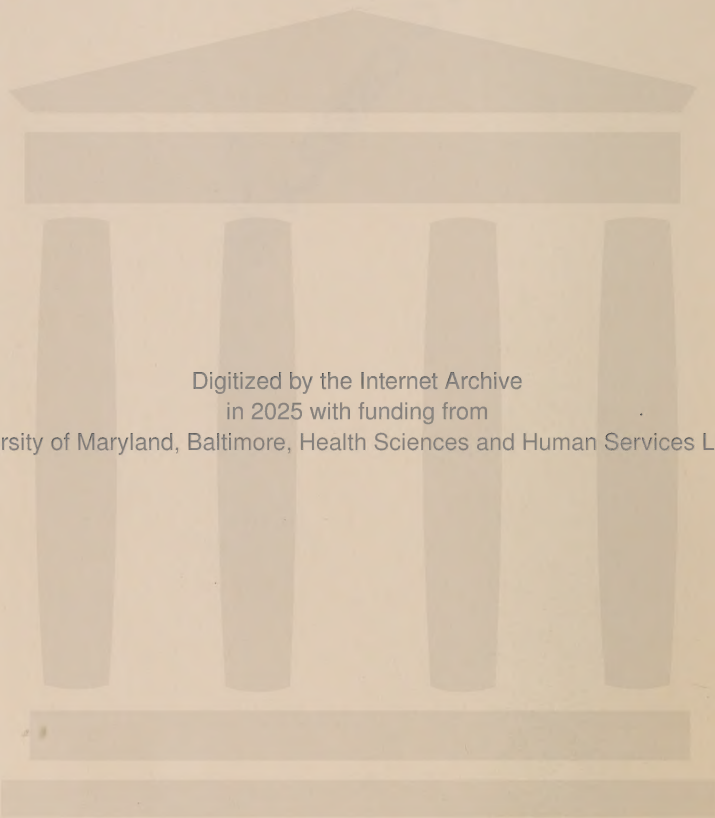


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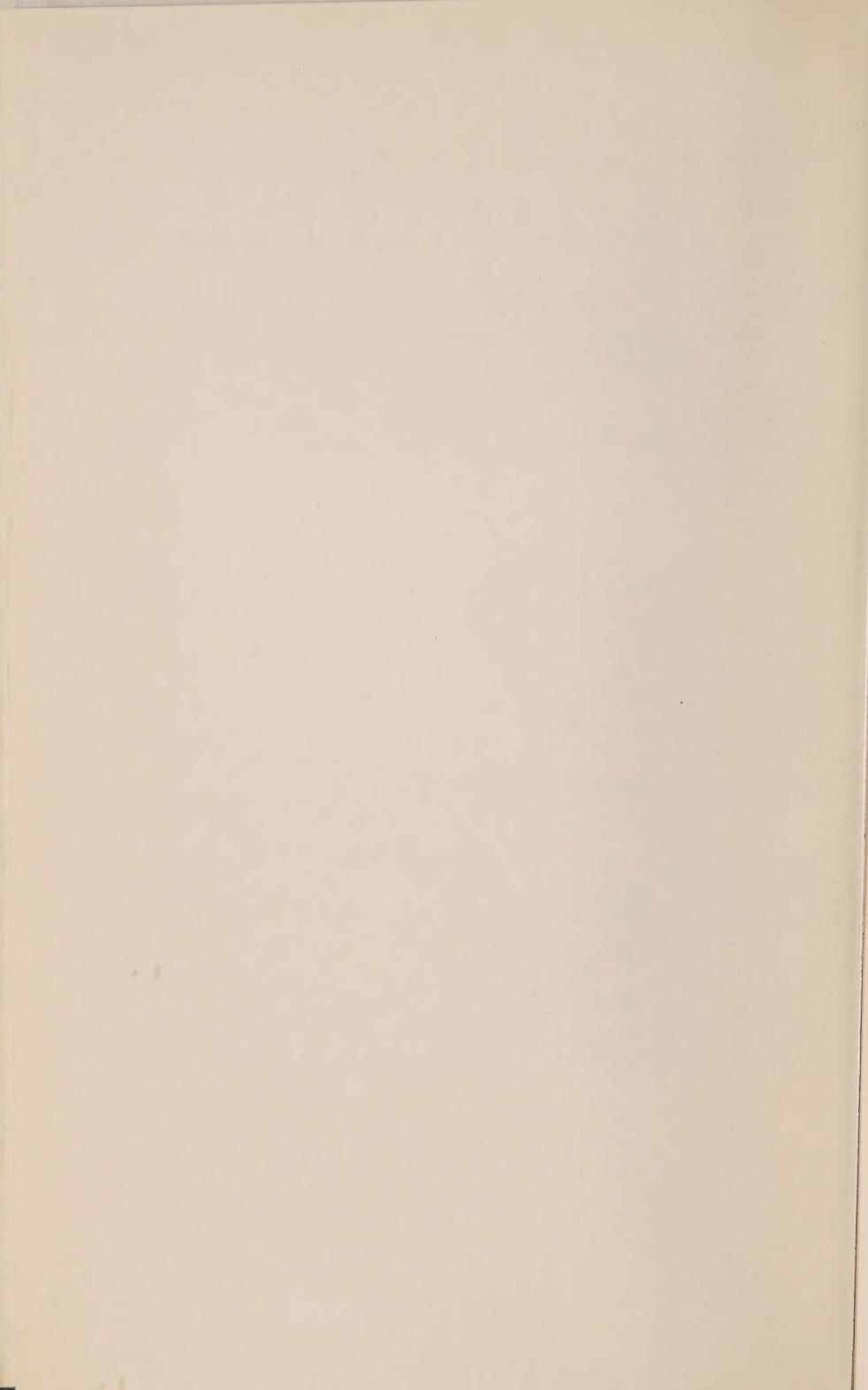
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Evaluation of Airborne Contamination In a Dental School Clinic

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Evaluation of Airborne Contamination In a Dental School Clinic

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SUMMARY

An evaluation of both airborne contamination levels and the efficiency of the air filtration system servicing the clinic areas on the first floor of the new University of Maryland Dental School was made. This study in dental aerobiology quantitates and compares the numbers and particle size ranges of viable particles (VP) found in the environmental air of the first floor clinic areas. Results obtained from sampling 7200 cu. ft. (4 hrs/day/5 days) of environmental air in the clinic contained 6469 VP representing airborne contamination levels of approximately 1 VP per cu. ft. of air sampled. Control air samples (1440 cu. ft. of air) collected during a weekend when no dental activity prevailed gave airborne contamination counts of 2 VP per 100 cu. ft. of air sampled. Although these two values (1 VP/cu. ft. and 2 VP/100 cu. ft.) represent a 50-fold increase of airborne contamination in the air of the clinic during normal dental activities, minimal VP exposure to patients exists. Particle size gradients determined for VP show that airborne particulates of $<8.5 \mu\text{m}$ were present in 84% of the aerosol particles recovered from the air of the clinic. Such particles, should they contain

infectious material, present a hazard of airborne infection in the lower regions of the respiratory tract.

The minimal VP recoveries, however, do indicate that the procedure of using a 50-50 air dilution (recycled clinic air with outside air) followed by passage of the air through a coarse air filter and a final air filtration by a high-efficiency biological filter which removes 90 to 99% of all airborne particles in the 1 to 5 μm size range is an effective one which promotes entry of "clean air" into the clinic environment.

INTRODUCTION

During the past dozen years, the theory of airborne infection has received much attention from all areas of biomedical activity. The role of aerobiology in dentistry was documented by Burton and Miller¹ in 1963. In 1932, before the era of modern dental techniques, Salzmann and Appleton² reported on 31 dentists and a dental hygienist who were infected with nonvenereal syphilis while providing dental treatment. A review of student health records from 1957 through 1962 at the University of California Medical Center, San Francisco, indicated that dental

students there had 150 to 190 dispensary visits per 100 students per year for treatment of respiratory infection.¹ Pharmacy and medical students on the same campus had 40 and 140 visits respectively per 100 students per year. More recently, Grundy,³ in the United Kingdom, Miller and others,⁴ Lorato and others,⁵ and Knighton⁶ have documented the risks of airborne infection by dental aerosols.

The modern air-driven handpiece is a versatile instrument that has advantages for both operator and patient. It has however created what practitioners believe is a serious health hazard—airborne microbial contamination. The role microorganisms play in the initiation of infectious disease may be enhanced greatly by inhalation of aerosols generated from the oral cavity by contemporary dental procedures. These microorganisms may cause a variety of diseases, including pulmonary tuberculosis, pneumonitis, influenza, viral hepatitis, as well as certain fungal and viral respiratory infections.

Grundy,³ in a survey of more than 600 dentists who were using the air turbine, found that 13.5% had developed physical symptoms (other than auditory discomfort) attributable to the high-speed drill. Travaglini and his associates⁷ indicated the presence of organism-bearing droplets when high-speed equipment was used. Madden and Hausler,⁸ Brown,⁹ and Terranova¹⁰ have described the role of the high-speed dental handpiece in forming microbial dental aerosols, and the adverse conditions resulting from use of that equipment.

Studies of aerosol clouds have revealed that an infectious disease

problem has the capability of existing, but to our knowledge no definitive epidemiologic studies have been conducted involving the patient, handpiece or other aerosol-producing instrument, dentist and other patients. Dentists report that they have had more upper respiratory infections and more skin infections of the face since using this type of equipment, but so far no quantitative data have been reported to substantiate this claim.

The application of aerobiologic principles to the study of airborne contamination in dentistry has demonstrated that dental aerosols may be a potential health hazard to dental personnel as well as to patients. Some of the hazards have been discussed earlier in this paper. Unlike controlled laboratory procedures, variables are the rule in most clinical studies of dental aerosols when reported in the literature. For instance, though basic dental procedures are essentially the same, some investigators may report their findings on dental aerosols generated by the air-turbine handpiece by using different air-water-oil spray flow rates than others making similar studies. Naturally, the results of such studies will reflect wide variances in both concentration levels of microbes as well as differences of recoveries of certain types of organisms from these aerosols. Both factors appear to be a function of particle size as well as response to clinical environments and the equipment used to sample the aerosols.

Wells¹¹⁻¹³ in earlier studies of aerosols of human oral organisms and later interpretations by Duguid¹⁴ and Meyers^{15, 16} have demonstrated rather conclusively that

particle size is important with respect to respiratory penetration. They reason that each droplet size range has a different etiological significance: droplets initially over 100 μm in diameter, which are not impinged on some surface directly, quickly fall on the floor, and droplets with diameters smaller than 100 μm evaporated to form "droplet-nuclei" which could remain airborne for many hours or days. The author¹⁷ has conducted aerosol studies under conditions of zero gravity in a rotating drum¹⁸ and shown that aerosol particles initially ranging in size from 1-5 μm containing rickettsiae (*Coxiella burnetii*) remained airborne and virulent for six days.

The visible ballistic splatter of large particles (>100 μm) easily seen in the dental operator when the air-turbine handpiece, water and air syringes, or rotating cups, brushes and discs are used is described by Wells as "direct dissemination." True aerosols consisting of smaller particles (100 μm) are dispersed in the same way as larger droplets, but the formation of invisible particles which float in the environment may remain suspended for many hours before settling to the floor. This he termed "indirect dissemination." Such invisible aerosols may consist of any combination of oral secretions, viable microorganisms, enamel and dentin dust, and metallic particles or vapors from dental restorations or prophylactic procedures.

Investigations¹⁹ on the propagation of aerosols by dental procedures containing viable particles (VP) less than 5 μm were first reported in 1947. Hoffman's²⁰ was one of the first dentally oriented articles which questioned office air

hygiene. He concluded that the dentist carries out a number of procedures that involve real risks of aerial transmission of diseases. More recently studies on dental aerobiology by Burton and Miller¹ and by Micik et al²¹, in the former case in an open dental suite and in the latter in a controlled environment operatory with a specially designed human aerosol test chamber, indicated that: (1) there is presumptive evidence that a potential health hazard exists, and (2) dental personnel should not permit repeated exposure to microbial aerosols with concentrations equal to or exceeding those produced by naso-oral activities considered unsanitary for the "intimate space" occupied. By "intimate space" group activity one is referred to Hall's²² classification of the space zones which people (consciously or unconsciously) maintain from each other during common social activities. Intimate (0 to 45 cm), personal (60-120 cm), social (1.2-3 m), and public (over 3 m) are the four distance zones involved in personal associations. Naso-oral activities such as a direct sneeze or cough are not usually conducted within the "intimate" or "personal" space of another. The dentist, however, must by necessity maintain a position within an intimate distance of his patient during most dental procedures.

A recent study²³ has dealt with the control of dental aerosols in small dental operatories by using a constant flow of air through high efficiency particulate air filters (H EPA) into the operatory (i.e., laminar airflow) to wash the environment clean of aerosol particles and to minimize exposure of dental personnel and patients to a potential hazard of airborne infection. Obvi-

ously, such an aerosol control system was not available at the time of construction of the new University of Maryland Dental School. However, some consideration of controlling airborne contamination in dental aerosols was discussed in formulating the design concept of the air conditioning system for the new dental building.

This study in dental aerobiology quantitates and compares, under controlled conditions, dental aerosol particles with respect to presence of viable microbe-containing particulates as well as an evaluation of particle size ranges in aerosols produced during dental procedures. Also, some effort will be made to assess the potential risk of airborne infection based on exposure to varying particle sizes assayed from the environmental air to patients and associated dental personnel while working in a teaching clinic.

MATERIALS AND METHODS

The two aerosol sampling techniques used in this study involve: (1) a Reyniers* slit sampler^{24,25} (Model FD-100) which is a 60-minute sequential viable particle air sampler; (2) an Andersen** cascade²⁶ (Model 0101) sampler which has been modified by May²⁷ to sample viable airborne particulates onto the seven collection stages stacked one upon another. The purpose of this arrangement allows for separation of the various sizes of airborne particulates onto agar plates at the appropriate gradient level of the sampler. In this way the larger airborne particles are deposited on agar plates in the upper

level and the smaller ones deposited on agar plates at the lower levels of the sampler. This procedure, therefore, gives one an accurate estimation of the sizes of airborne particulates which may be found in the environmental air of the dental clinic. Both types of aerosol samplers were calibrated to sample 1 cu. ft. of air per minute by the inline insertion of a critical orifice at the exhaust opening of each sampler.

Figures 1 and 2 are representative of the two types of air samplers used in this study.

Five Reyniers slit samplers and an Andersen sampler were situated in one of four teaching modules containing 32 cubicles in the two 128-cubicle general practice clinics located on the first floor of Hayden-Harris Hall, School of Dentistry, University of Maryland in Baltimore, Maryland.

The first floor is wholly dedicated to undergraduate clinical teaching and dental students in their third and fourth years of clinical study are permanently assigned to cubicles. Figure 3 shows the general layout of the first floor plan and Figure 4 shows the placement of aerosol sampling devices in one of the four teaching modules in the clinics.

Air sampling to establish the level of background contamination present in the clinic area was obtained on a weekend (Sunday). This provided for maximal circulation and filtration of air ventilating the clinic as well as minimal activity in the clinic following the last working day (Friday). Air was

*Reyniers & Son, 3806 N. Ashland Ave., Chicago, Ill. 60613

**Andersen Samplers & Consulting Service, 1074 Ash Avenue, Provo, Utah.

sampled >36 inches above floor level by both types of aerosol samplers at a rate of 1 cubic foot per minute into each sampler over a four-hour period (240 cu. ft.). Bacto blood agar growth medium (Difco-No. B45)*** with 5% sheep erythrocytes (BBL-No. 11945)**** incubated aerobically at 35 C for 48 hours was used in all microbial sampling plates. Counts of colonies taken from the incubated blood agar plates provided a quantitative estimate of VP, without estimations of actual microbial concentrations within VP.

The air conditioning system in the dental school is divided into two separate units. The first system services the ground, first and second floors. The second system, which is independent of the first system, operates with 100% outside air and services the third, fourth, and fifth floors. Air supplying the clinical modules comes from the first system and is diluted with 50% outside air in combination with air returning through the exhausts in the first system. The mixed air (50% outside — 50% returned exhaust) is then subjected to two levels of filtration. The large volume of air is passed through a roughing filter to remove large amounts of contamination and dust debris. These filters are designed to remove the bulk of large airborne particles and may remove from 10 to 60% of the bacteria and other particles associated with the organisms. In this instance the roughing filters are used as prefilters to remove large particle debris and to reduce "loading" of the high efficiency filters which follow. The

dry type of roughing filter used is composed of loosely packed fibers which offer more resistance to the passage of air and has a higher filtration efficiency than the viscous type.

The prefiltered air is then passed through high-efficiency biological filters of the Micretaint† or Aerosolve† type. These remove 90 to 99% of all particles in the 1 to 5 μ m diameter range. The filter media are chiefly glass fibers, good grades of fiber paper and asbestos fibers. The diameter of the fiber ranges from 1 to 5 μ m. Resistance to airflow is higher than that of either the roughing or medium efficiency filters, and increases appreciably as the filter loading increases. Characteristic of these filters is the ability of the media to carry a heavy microbial load before the resistance becomes excessive. Decker et al²⁸ have described methods of air filtration of microbial particles as they apply to biological aerosols.

Days for sampling of dental aerosols generated in the teaching clinics on the first floor of the Dental School were subject to alteration depending upon student work schedules. Chief consideration was given to sampling of aerosols when maximal student work included use of more than 16 of the 32 teaching modules in each clinic. During each air sampling period (60 minutes) an incoming filtered airflow of 3800 cu. ft. per minute was balanced by a similar exhaust from each clinic area. In any given clinic this represents a room air change every 7½ minutes of approximately 28,200 cu. ft. of air (87' x 36' x 9') or about 8 air changes per hour.

***Difco Laboratories, Inc., Detroit, Mich.

****Baltimore Biological Laboratory, Inc., Div. Becton, Dickinson and Co. Baltimore, Md.

†Cambridge Filter Corp., Syracuse, N.Y.

RESULTS AND DISCUSSION

Table 1 shows the recoveries of VP over a four-hour sampling time for each of the five days of testing in a clinical environment with dental aerosols. The control sample was obtained on a day (Sunday) in which activity in the clinic was at an absolute minimum. This procedure would allow estimation of levels of counts of VP existent during non-dental activity in the clinics.

Counts of VP obtained over the 5-day test period do not show any unusual differences among each of the sampling days. Recoveries of VP during the initial hour seem not at any great variance from those obtained during the fourth hour of sampling when build-up of residuals would be most likely. One of the most significant findings was

the very low VP counts taken during the control sampling period. The VP counts indicate that incoming air to the clinic has a very low background of microbial contamination and would not contribute significantly to the level of VP in the clinic during normal dental procedures. In terms of VP per cubic foot of air, the control samples show that for every 100 cubic feet of air passing into the clinic approximately 2 VP are recovered from the environmental air ($34 \text{ VP} \div 1440 \text{ cu. ft.}$). Aerosol samples taken during routine dental activities, however, show that for the 7200 cu. ft. of air sampled 6469 VP were recovered. This represents approximately 1 VP per cu. ft. of air sampled during the period of dental activity in the clinic and a 50-fold increase of airborne contamination.

Table 1—Total VP collected from clinic air at six sites* for four hours.

Days	SAMPLING TIME				Average VP/hr.	Total 4 hrs.	Total VP All samples
	1 hr.	2 hr.	3 hr.	4 hr.			
1	231 (.64)	271 (.75)	360 (1.0)	275 (.76)	284	1137 (.78)	
2	211 (.58)	256 (.71)	349 (0.96)	318 (.83)	283	1134 (.78)	
3	345 (.95)	341 (.95)	351 (.97)	349 (.96)	346	1386 (.96)	
4	480 (1.3)	384 (1.06)	309† (1.03)	357† (1.19)	382	1530 (1.15)	
5	266 (.73)	315 (.87)	271 (.75)	430 (1.19)	320	1282 (.88)	6469+
Control‡	14	4	7	9	8	34	34

* 5 Reyniers Slit and 1 Andersen Cascade Samplers.

† Data represents only 5 aerosol samplers in operation.

‡ Control sample obtained on non-work day (Sunday) and 1440 cu. ft. of air sampled through 6 samplers.

+ Data obtained by sampling 7200 cu. ft. of clinic air.

Data in parenthesis represents number VP per cu. ft. of air sampled. (total VP \div total vol. air sampled/60 min \times 6 sampling devices = VP/cu. ft. of air).

Particle size gradients shown in Table 2 indicate that airborne particulates of varying sizes were present in the environmental air of the clinic. The cumulative percentage of VP in size ranges of approximately 10 μm or less was

83 and particulates of 5 μm or less comprised 70 per cent of the aerosol particles. Except for the smallest particle gradient of 0.77 μm (3%) size gradients of VP were about evenly distributed over a 13-20 per cent range.

Table 2. Particle size gradients from dental aerosols collected in a teaching clinic.

Mass Median Diameter (μm)	VP	Percentage VP of Total Collected	Cumulative Percentage VP >0.7 but <8.5 μm
>8.5	198	16.5	—
8.5	161	13.4	83.5
5.6	185	15.4	70.1
3.7	179	15.0	54.7
2.5	254	21.2	39.7
1.4	186	15.5	18.5
0.77	36	3.0	3.0
Total	1199	100	

Aerosol collected in Andersen Cascade Sampler (modified).

Transmission of a number of diseases by the airborne route of infection has been established for a number of diseases^{29,30}, and as previously cited droplet-nuclei have been implicated as the primary mode of transmission. Wells^{11-13, 31} and Riley and O'Grady³² have described infectious particles that remain in the air as being dustborne and droplet-nuclei borne. Dustborne particles due to their large size are removed by sedimentation, but droplet-nuclei less than 5 μm in size are light enough to remain suspended for relatively long periods. Studies by Pelleu, Shreve and Wachtel^{33, 34} have demonstrated that high-efficiency filters have reduced the microbial concentration in the air of dental operating rooms.

Results obtained in this study indicate that viable airborne particulates were reduced to less than 1

VP per cu. ft. of air sampled (6469 VP \div 7200 cu. ft. of air sampled = 0.9 VP per cu. ft. of air). The air conditioning system as designed to utilize a 50% dilution of recirculated exhaust air from the clinic with outside air and passage through both a roughing and a high-efficiency filter appears to reduce the level of airborne particulates in the clinic to minimal levels.

With turbulent flow, it is immediately obvious that even if all air entering the clinic is sterile, this sterile air mixing with the clinic air merely dilutes and carries away a portion of any aerosol generated within the room and does not assure a sterile environment. If ventilation and generation of the aerosols within the clinic are constant, which in this case they are not, the concentration of the organisms in the air will, in time, reach an equilibrium or steady concentration.

The exact value of this concentration will depend, of course, upon the rates at which the aerosol is being produced, the methods and velocities by which the diluting air is supplied to the clinic, the degree of contamination, if any, and of the exhaust locations and velocities by which the mixture is removed.²⁸

The ventilation system servicing the clinics on the first floor was designed to displace contaminated air with clean entering air, with minimal turbulence mixing under a balanced air flow. Employing multiple ceiling inlets supplying a 3200 cu. ft. per minute inflow the air is exhausted by outlets at a similar flow rate velocity in an attempt to produce streamlined flow. Thus, any point in the clinic is being washed by air from above, and the contamination of the air at any elevation will depend only on the contamination introduced into the air at or above that point. However, completely non-turbulent displacement is a difficult, if not impossible, condition to obtain, and relatively high-velocity streams of sterile air may have to be used in place of low-velocity displacement. Such an alternative choice of high-velocity sterile airflows through the use of HEPA filtration and vertical downflows of air resulting in removals of airborne contaminants in excess of 99% from the air in small dental operatories has been mentioned.²³

Although the epidemiology of respiratory infections among dental personnel remains virtually unexplored, enough presumptive evidence of this method of disease transmission exists in the literature to speculate on its potentialities in dentistry.

Cuthbertson³⁵ reported that, in the United States in 1952, deaths of 11.2% of 858 dentists were at-

tributed to sensory organ or nervous system disease attributable to poliomyelitis. Contrasting this with 0.03% among males generally, he has speculated that poliomyelitis may have been an occupational disease hazard for dentists because of close contact with their patients' respiratory tracts.

Definite correlation between the incidence of epidemics of common colds and other respiratory illness in new naval recruits and in the dental personnel who treated them has been reported.³⁶ At the same naval base, similar incidence did not occur among dental personnel treating seasoned recruits and cadre personnel.

Although these and other reports^{1, 37-40} of occupationally incurred respiratory infection of dentists are limited, much has been reported in medical aerobiology to provide strong arguments for investigation of this potential occupational hazard.

The common cold, viral respiratory diseases, tuberculosis, and other diseases caused by airborne microorganisms constitute the greatest public health problem in terms of man hours lost due to illness.⁴¹ Furthermore, aerobiologists have repeatedly demonstrated air-born transmission of diseases not naturally transmitted by the airborne route, such as tularemia, Rocky Mountain spotted fever, and possibly viral hepatitis.^{42, 43} The primary source of man's infectious respiratory disease is his fellow man.^{32, 44}

Studies by Riley and O'Grady³² determined that, in a tuberculosis ward, one unit or quantum of tuberculosis infection was contained in approximately 680,000 liters of air. They calculated six months' exposure for ward personnel to in-

hale one quantum. On the basis of a report by Belting et al⁴⁵, the time required for exposure to one quantum of infection when performing dental procedures on patients having tuberculosis was considerably less (one-half day to one week).

Further, recent studies by van Houte et al⁴⁶ show that the relative absence of *Streptococcus sanguis* in human feces, in contrast to its high concentration on teeth incorporated in dental plaque, supports the concept of the mouth as the likely bacterial source in cases of subacute bacterial endocarditis involving this organism. Alpha-hemolytic streptococci form the single most numerous group of bacteria associated with subacute bacterial endocarditis.⁴⁷ Of these streptococci, *Streptococcus sanguis* (*Streptococcus* s.b.e.⁴⁸) has been found in over one-third of the cases.⁴⁹⁻⁵³ Work by Carlsson^{54, 55} suggests that *S. sanguis* preferentially colonize the tooth surface and are constantly present in dental plaque. He further suggests that the tissues surrounding the teeth are the main sites of entrance of *S. sanguis* in the blood stream.⁵⁴

Although the infecting organisms in subacute bacterial endocarditis cases are of diverse origin, the human oral cavity has long been considered as an important source as it has been shown to harbor numerous other infectious agents albeit transiently. Here, three factors may predispose the possibility of airborne infection in the dental clinic with streptococci: (1) the release of streptococci in small particulates ($<5 \mu\text{m}$) from plaque by ultrasonic scaling procedures during prophylaxis, (2) that the propensity of such small particles to impinge in the alveoli where lung clearance is difficult, and (3) the

fact that streptococci appear to remain viable and is not adversely affected by the average relative humidity of an office or clinic environment.⁵⁶

The importance of the role of particle size in airborne infections cannot be stressed too vigorously. As mentioned earlier, the smaller the particle bearing infectious organisms the greater the chance of impingement in the lower respiratory tract. Further, small particles also influence inhaled doses enough to lower the threshold of infection susceptibilities. Recent studies by Day and Berendt⁵⁷ show conclusively that airborne infection of rhesus monkeys with *Pasteurella tularensis* is greatly influenced by particle size. Their studies show not only do small particles influence inhaled doses but also determine onset of illness. For instance, particles in size ranging from 2.1 - 7.5 μm median diameters showed 100% infectivity and extensive infection of the lower respiratory tract. Monkeys exposed to 12.5 or 24.0 μm median diameter particles presented involvement of the cervical and mandibular lymph nodes. Onset of clinical illness from exposure to small particles (2 μm) occurred in 2 to 3 days after exposure from inhaled doses of <5 cells. Illness due to inhalation of larger particles (24 μm) had an onset of 6 to 10 days with inhaled doses of 340 cells. This represents a 68-fold increase in the ID_{50} dose required for large particles. Such studies in primate hosts give some indication that this phenomena could easily be extrapolated to man and his exposure to potentially infectious organisms in dental aerosols.

Therefore, without some thought being given to the control of the dissemination of the contents of

the mouth by dental procedures and to filtration of the air in dental clinics the potential for airborne infections resulting from such practices will continue to be dentistry's air pollution problem to the detriment of human public health.

CONCLUSION

To summarize, earlier studies²⁸ of filtration of airborne particulates have shown that there is a considerable reduction in concentration of viable organisms when the 90% (high) efficiency filter is used in contrast to filtration with a 60% (roughing) filter. Thus, there is considerable benefit derived from using a high-efficiency filter (90%) as opposed to a relatively inefficient one (60%). Also little additional benefit is gained by using a filter which is essentially perfect (99%), or by supplying completely clean air from an outside source if distribution in the room results in turbulence. In view of this, use of the high-efficiency filter is recommended for use where turbulent mixing is employed.

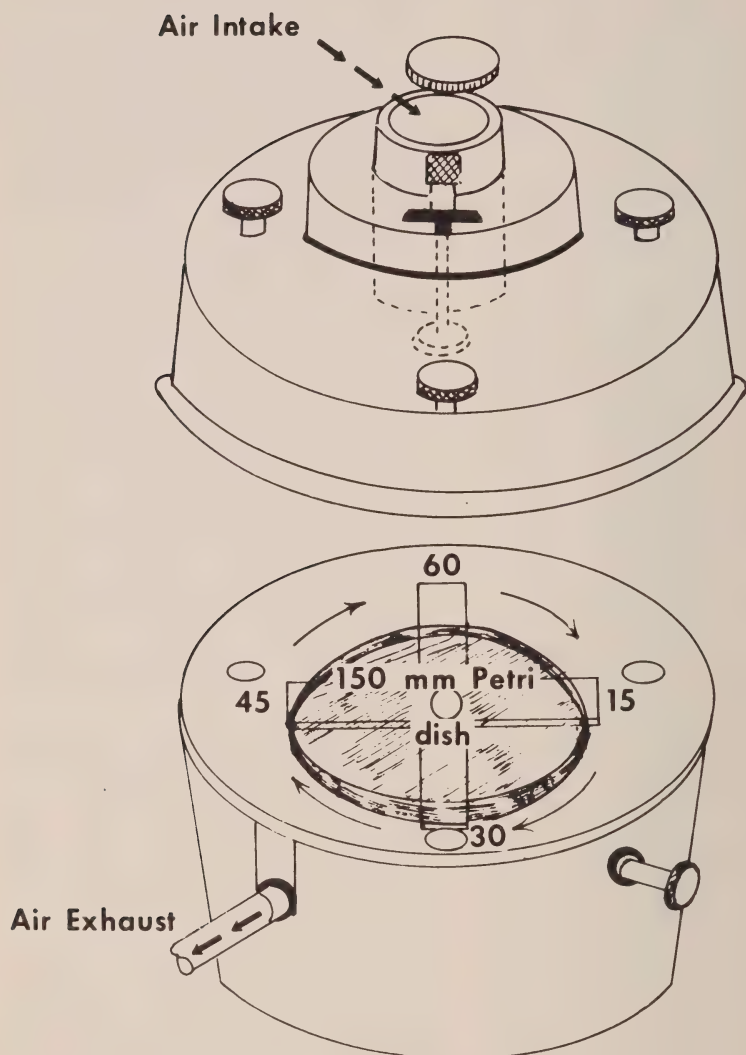
The arrangement of utilizing a 50-50 air dilution of return air from the clinic area in the dental school followed by passage of the air through a roughing filter and thence through a high efficiency filter allows for little return of viable particles to the clinic environmental air. Data obtained from air sampling studies indicate that less than 1 VP per cu. ft. was collected on the average from six sampling sites over a five day test period. Viable particle concentration ranges of 1.15 to 0.78 per cu. ft. of air were demonstrated from 6469 VP collected in 7200 cu. ft. of air sampled. Therefore, the overall risk of exposure of patients to a high density of dental aerosol par-

ticles has been minimized as the air filtration system appears to be an efficient one.

The risks of airborne infection, however, remain the highest for those dental students who do not wear protective masks and safety glasses. This is due to working in close proximity to the point of aerosol generation before air circulation can effect any dilution factor on the dental aerosols.

Particle size data shows that approximately 83% of the particles collected have median diameters ($<8.5 \mu\text{m}$) and that 70% are particles with $5.6 \mu\text{m}$ median diameters. Such VP can penetrate to the lowest levels of the respiratory tract and may probably be more responsible for initiating infection with smaller inhaled doses. Although larger inhaled doses may be required, large particles ($>10 \mu\text{m}$) containing potentially infectious organisms cannot be overlooked because these airborne particles can cause infections in the middle and upper respiratory regions.

Finally, these tests indicate that the air handling system as designed appears to be reducing the number of airborne particulates from returning to the clinic area. The absence of viable particles in the return air helps to minimize the risks of exposure to infectious material from dental aerosols which are constantly being generated and disseminated throughout the clinic environment. It must be stressed, however, that filtered air alone cannot minimize the hazards of exposure to the dentist unless a conscious effort on his part is made to wear the necessary protective devices and to use air evacuators extensively when using equipment which generate these aerosols.



Schematic Diagram of Reyniers Slit Sampler

Figure 1.

SCHEMATIC DIAGRAM OF A SEVEN STAGE ANDERSEN SAMPLER

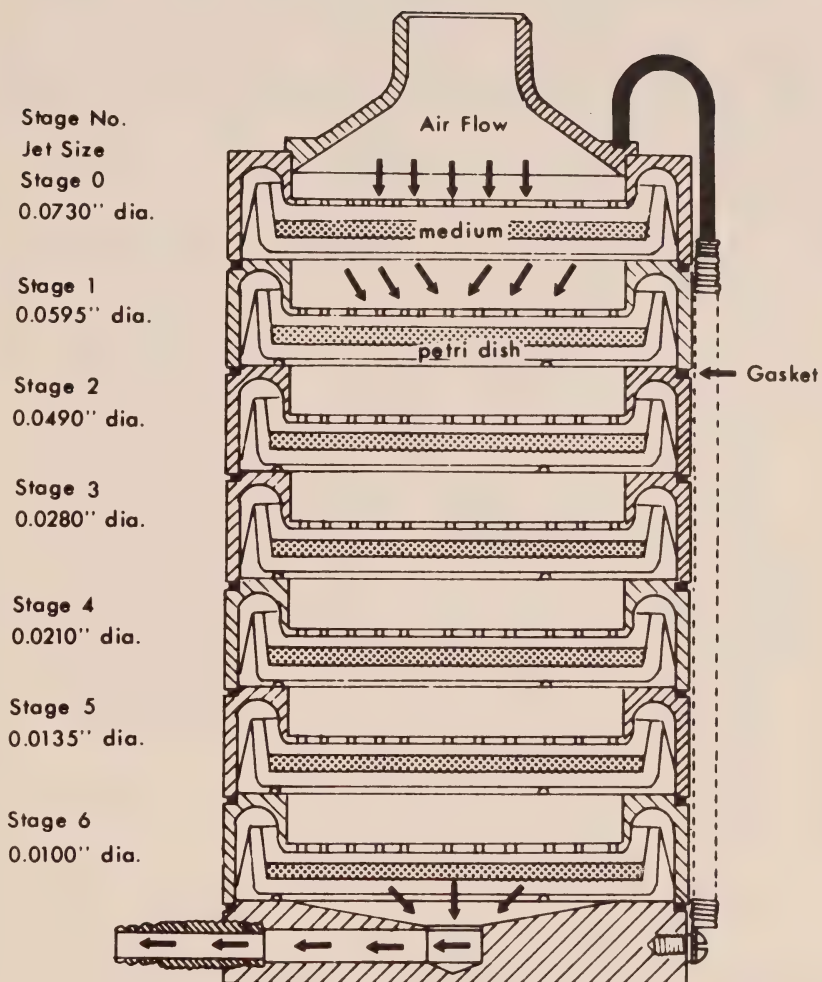


Figure 2.

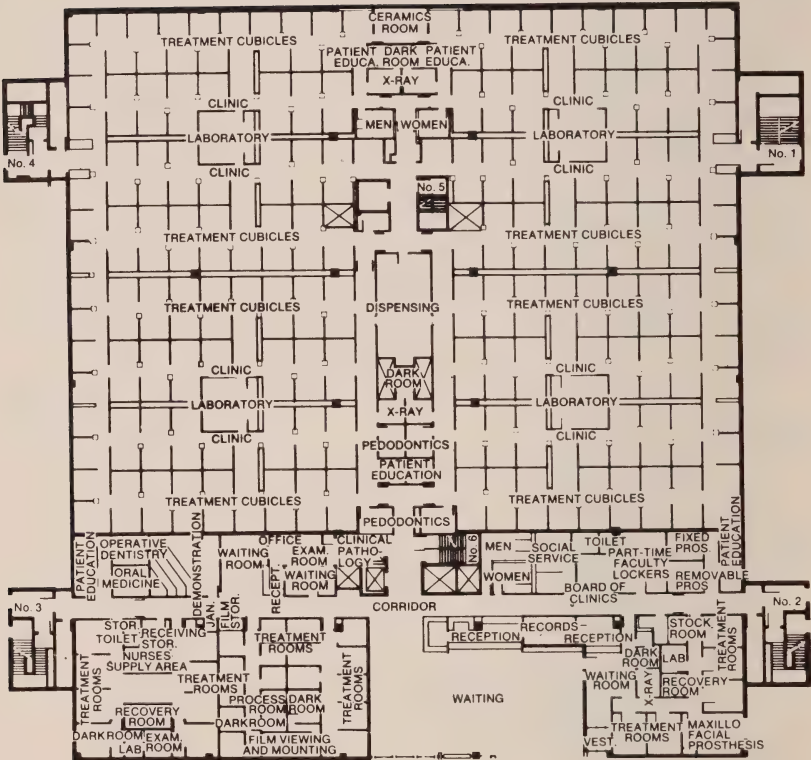


Figure 3. First floor plan of Hayden-Harris Hall of the Baltimore College of Dental Surgery of the School of Dentistry of the University of Maryland.

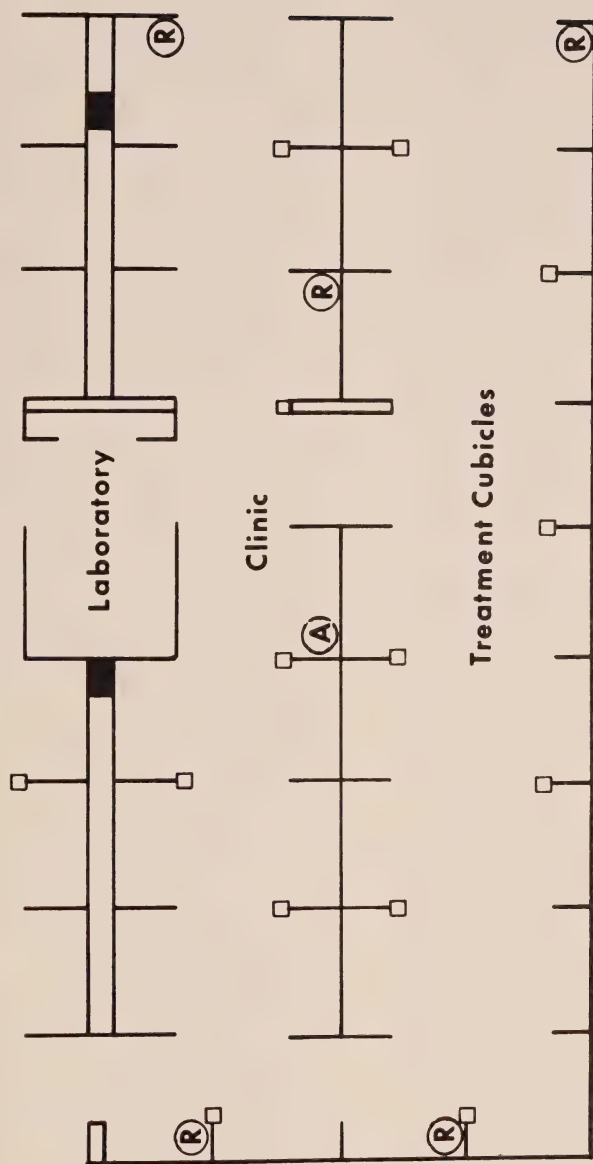


Figure 4. Treatment cubicles showing placement of aerosol sampling devices.

A — Andersen Sampler
R — Reyniers Slit Sampler

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Establishment of Reliable Baseline Data for Dental Research

PART I. USAGE OF SECONDARY DATA SOURCES

DOROTHY GALLANT* AND STEWART SHAPIRO**

Establishment of Reliable Baseline Data for Dental Research

PART I. USAGE OF SECONDARY DATA SOURCES

DOROTHY GALLANT* AND STEWART SHAPIRO**

Summary

This study evaluates the associations between intelligence and oral health. However, the prevailing object of this report is the demonstration of the pitfalls that dental researchers are prone to, especially in regard to the utilization of secondarily secured data.

Information

It is the primary objective of this series of reports to demonstrate the need for the actual accumulation of preliminary data by the investigators themselves. The secondary objective of these reports will be the identification of the limitations of utilization of data obtained by other sources. The technique for this series will incorporate various population isolates. The authors will identify the strengths and weaknesses of data obtained in "real" studies, not conceptual models. The first part of the series will direct itself toward the interpretation of data describing the relationships of age, highest school grade of education completed, and educational and intelligence quotient levels all relative to oral and dental health profiles. It must be emphasized that the re-

search objective of the study described was to evaluate the associations between measured intelligence and the status of oral health. The information requested was primarily for the benefit of the dentist as the researcher, not the behavioral scientist. The dental researcher must be aware of the limitations of the utilization of data obtained from secondary sources for correlative dental health studies.

Methods

Dental examinations were completed on all the female inmates of a correctional institution during December, 1969. The indices used to measure the oral health status were the DMFT (Decayed, Missing, Filled Tooth) Index¹, the OHI-S² (Simplified Oral Hygiene Index), and the P.I.³ (Periodontal Index). The examinations were conducted in the dispensary of the institution. The actual examination was conducted with the use of mirror, explorer, and adequate illumination. Radiographs were not used. All examinations were completed by one dental examiner, who was calibrated in survey examination technique.

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A records review was completed to furnish data relative to I.Q., California Grade Achievement scores, and ascertainment of highest school level of education achieved by the subject.

It must be emphasized that the intelligence testing for the aforementioned variables was accomplished previously by other individuals and not by these investigators. Due to the variability under which the testing had been completed, the reliability and validity of the resultant data must be carefully interpreted. The ascertainment of highest level of education achieved is the most reliable basis for evaluation, since such ascertainment was verified by written documentation from the appropriate educational institutions.

Results

Examinations were completed for 154 subjects comprising the entire institutionalized population. The mean age distribution for the 154 subjects was 28.74 (± 9.8) years. 59 subjects were between ages 16-30 years of age and comprised 44% of the total population. There were 116 black subjects with a mean age of 28.73 (± 10.23) years, and 38 white subjects with a mean age of 28.76 (± 9.33) years, (Table 1).

The overall mean DMFT score was 16.58 (± 6.56). There was a statistically significant difference between the mean DMFT score of 15.70 (± 6.26) for the black subjects as compared to the mean DMFT score of 19.23 (± 6.79) for the white subjects, (Table 1). The over-all mean P.I. score was 1.64 (± 1.72), (Table 2), and the over-all mean OHI-S score was 1.36

(± 1.25), (Table 3). There were no significant differences between the mean P.I. and mean OHI-S scores by race.

Considering the Mean DMFT Score as the independent variable, there was a statistically significant relationship between mean DMFT Score and mean age, (Table 1). However, there were no significant differences between mean DMFT scores and mean grade levels of education, (Table 1), mean I.Q. scores, or mean California Achievement Scores. The results were similar within each race.

When the mean P.I. Score was considered as the independent variable, there was a statistically significant relationship with mean age, (Table 2), but not with mean grade level of education, (Table 2), mean I.Q. Scores, or mean California Achievement Scores. The results were also similar for the black subjects. However, there was no statistically significant relationship between mean age and mean DMFT Score for the white subjects; as was the case for the other dependent variables as well.

No statistically significant relationships were found between mean OHI-S Score and mean age, (Table 3), mean grade levels of education, (Table 3), mean I.Q., or mean California Achievement Scores, for the entire population. There was, however, a significant relationship between OHI-S and mean age, but for the black subjects only.

It should be clarified at this point, that although similar statistical analysis were completed for all variables, only data for the dependent variables of age and level of education is provided in

Tables 1, 2, and 3. The authors could not foresee any advantage of the inclusion of other data to complicate the tables. This data is available from the authors should it be desired.

Discussion

The most important question to be answered at this time is "how reliable are these results?" If the authors desired to employ these results to plan a dental study based on the variables of age and highest grade level of education achieved, the results are reliable and valid. On the other hand, although the results might be considered as indicators, the data relative to Intelligent Quotient and California Achievement Scores is not reliable.

The dental examinations were completed by a calibrated examiner adhering to strict criteria. Data describing the oral profiles are reliable and valid. The epidemiological description of the oral health profile can be used (1) to project sample size determinations for similarly institutionalized population isolates, (2) to provide baseline data for evaluation of dental delivery systems within a similar environment, (3) to evaluate changes in dental health habits relative to existing dental programs, and (4) for a vast number of other study objectives.

In this study, for each subject, the highest level of grade of educational achievement was ascertained by documentation from appropriate school administrations. Therefore, correlative studies within this population between age and grade level of education, with oral profile scores are reliable and valid. This is true only because the investigators have controlled the in-

put of data themselves. They can only accept the oral health scores recorded by themselves (following strict epidemiologic specification) and data available in the personal records of subjects which clearly and definitively contains documents of ascertainment.

However, we must direct our attention toward the negative side of this study. The collection and analysis of data relative to the Intelligence Quotient Scores and California Achievement Scores identifies factors which must be accounted for in the final conclusion. The data appears to be reliable, but it is not acceptable. There are several discrepancies which even the most sophisticated statistical analysis cannot overcome and validate. For example, there was no way to determine the conditions under which the individuals completed their intelligence tests; whether they were administered individually, or in groups, the time of testing in relation to time of incarceration, emotional attitudes, the general environmental influences, such as available lighting, seating, and a multitude of other factors, which could influence behavioral attitudes. In addition, there was no identification of the particular testing instrument employed. There may have been a variety of tests from which the I.Q. ratings were recorded. The I.Q. and California Achievement testing, may have been done according to the Revised Stanford-Binet Scale, the Wechsler Adult Intelligence Scale, the Wechsler-Bellevue Intelligence Scale, and/or any of the host of California Achievement Tests designated by the California Test Bureau. In one bibliography⁴ listing all the tests available in print there were 238

Intelligence Tests and 45 Achievement Tests. Therefore, since the resultant test scores were recorded in the personal records without reference to the specific instrument used, any correlative studies using this data would not be valid.

In order to utilize intelligence data to correlate actual grade level of schooling accomplished, with the oral profile, testing must be conducted under the close scrutiny of the investigator.

This presentation is founded in a real situation. A portion of the data accumulated is reliable and valid; that portion was attained via two separate routes. One section of the data was obtained by the actual examination of subjects according to specially designed criteria. The other group of reliable data was obtained via a records review. The latter information is reliable only because of careful school administration ascertainment of highest grade attended in school. However, this study suggests that investigators must use extreme caution when employing data accumulated by others. Unless carefully validated, dental researchers must hesitate to employ secondary research information of data obtained from a secondary source. In future reports, this series will direct itself toward identifying sources of weakness in employing "onhand" information to complete investigations. Those investigators who will be involved in population studies should consider these factors before initiating costly and time-consuming studies. Part two of this series will document a possible danger involved in sample size determinations.

Conclusion

This presentation is unique in

that it presents conclusions derived from two viewpoints. The results of this study present hard data discussing the statistical relationships of oral health profiles of institutionalized females to (1) chronologic age and (2) highest grade level of education attended. In addition, it identifies supportive secondary data (although supportive in a positive direction) which must be considered as unreliable, and suggests its acceptability only as an indicator.

The following conclusions can be described from this study.

1. There was a significant relationship between increased chronologic age (years) and increased mean DMFT and mean P.I. Scores. This was not the case when mean OHI-S Score was the independent variable.
2. There were significant relationships between mean DMFT Scores and age by race. Significant findings were obtained for only the black subjects when the mean OHI-S and P.I. Scores were the dependent variables.
3. There were no significant relationships between highest grade level of school attended and the mean DMFT, OHI-S, and P.I. Scores, overall, or by race.

At this point, several conclusions relative to data sources can be expressed.

4. Data obtained (from records) which is not ascertained, cannot be considered reliable, even though it positively supports reliable data.
5. Data which is obtained from a variety of uncontrolled sources cannot be considered reliable.

6. Although there were no statistically significant relationships of oral health profile to I.Q. and California Achievement Scores, the results may

still be accepted but only as indicators suggesting the lack of significant associations.

TABLE 1

Statistical Analysis of Significance for Mean DMFT (Decayed, Missing, Filled Teeth) Scores as the Independent Variable (X) with Mean Age in Years, and Mean Years of Educational Level Achieved as Dependent Variables (Y), for Incarcerated Females at the Maryland Educational Institution for Women.

INDEPENDENT VARIABLE (X)—DMFT ($\bar{x} = 16.58 \pm 6.56$)						
Population Selection	Dependent Variable (Y)	Mean	Correlation X vs. Y	Regression Coefficient	"t" Value	Analysis of Variance(d)
Total = 154	Age Grade Level	28.74 (± 9.98) ^b 8.25 (± 3.53)	0.51 0.10	0.78 (± 0.10) ^c 0.05 (± 0.04)	7.42† 1.36	55.14† 1.86
INDEPENDENT VARIABLE (X)—DMFT ($\bar{x} = 15.70 \pm 6.26$)						
Non-White N = 116	Age Grade Level	28.73 (± 10.23) 8.11 (± 3.34)	0.53 0.15	0.87 (± 0.12) 0.08 (± 0.04)	6.85† 1.70	47.04† 2.89
INDEPENDENT VARIABLE (X)—DMFT ($\bar{x} = 19.23 \pm 79$)						
White N = 38	Age Grade Level	28.76 (± 9.33) 8.69 (± 4.07)	0.49 -0.04	0.65 (± 0.19) -0.02 (± 0.09)	3.51† -0.27	12.29† 0.07

(a) Highest level of education completed (yrs.)

(b) Standard deviation of the mean

(c) Standard error of regression coefficient

(d) F—Value

* Significant at 95% Level

† Significant at 99% Level

TABLE 2

Statistical Analysis of Significance for Mean OHI-S (Oral Hygiene-Simplified) Scores as the Independent Variable (X) with Mean Age in Years, and Mean Years of Educational Level Achieved as Dependent Variables (Y), for Incarcerated Females at the Maryland Correctional Institution for Women.

INDEPENDENT VARIABLE—OHI-S ($x = 1.36 \pm 1.25$)						
Population Selection	Dependent Variable (Y)	Mean	Correlation X vs. Y	Regression Coefficient	"t" Value	Analysis of Variance(d)
Total N = 154	Age Grade Level ^a	28.74 (± 9.98) ^b 8.25 (± 3.58)	0.09 0.03	0.79 (± 0.64) 0.09 (± 0.22)	1.24 ^c 0.40	1.55 0.16
INDEPENDENT VARIABLE—OHI-S ($x = 1.40 \pm 1.24$)						
Non-White N = 116	Age Grade Level	28.73 (± 10.23) 8.11 (± 3.34)	0.21 0.01	1.72 (± 0.74) 0.04 (± 0.24)	2.30* 0.16	5.30* 0.03
INDEPENDENT VARIABLE—OHI-S ($x = 1.22 \pm 1.26$)						
White N = 38	Age Grade Level	28.76 (± 9.33) 8.69 (± 4.07)	-0.26 0.09	-1.93 (± 1.17) 0.29 (± 0.52)	-1.64 0.55	2.71 0.30

(a) Highest level of education completed (yrs.)

(b) Standard deviation of the mean

(c) Standard error of regression coefficient

(d) F—Value

* Significant at 95% Level

† Significant at 99% Level

TABLE 3

Statistical Analysis of Significance for Mean P.I. Scores (Periodontal Index) as the Independent Variable (X) with Mean Age in Years, and Mean Years of Educational Level Achieved as Dependent Variables (Y), for Incarcerated Females at the Maryland Correctional Institution for Women.

INDEPENDENT VARIABLE (X)—P.I. ($x = 1.64 \pm 1.72$)

Population Selection	Dependent Variable (Y)	Mean	Correlation X vs. Y	Regression Coefficient	"t" Value	Analysis of Variance(d)
Total N = 154	Age	28.74 (± 9.98) ^b	0.20	1.20 (± 0.45)	2.64†	7.00†
	Grade Level	8.25 (± 3.53)	-0.00	-0.01 (± 0.16)	-0.06	0.01

INDEPENDENT VARIABLE (X)—P.I. ($x = 1.66 \pm 1.78$)

Non-White N = 116	Age	28.73 (± 10.23)	0.27	1.59 (± 0.51)	3.10†	9.64†
	Grade Level	8.11 (± 3.34)	-0.07	-0.13 (± 0.17)	-0.76	0.59

INDEPENDENT VARIABLE (X)—P.I. ($x = 1.59 \pm 1.56$)

White N = 38	Age	28.76 (± 9.33)	-0.05	-0.33 (± 0.97)	-0.34	0.11
	Grade Level	8.69 (± 4.07)	0.18	0.49 (± 0.42)	1.17	1.37

(a) Highest level of education completed (yrs.)

(b) Standard deviation of the mean

(c) Standard error of regression coefficient

(d) F—Value

* Significant at 95% Level

† Significant at 99% Level

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Establishment of Reliable Baseline Data for Dental Research

PART II. DISCREPANCIES IN SAMPLE SIZE DETERMINATIONS

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SUMMARY

This segment of the series, devoted toward discussions of baseline data for dental research, displays pitfalls confronting both the dental researchers and administrator, especially in sample size determinations. It also emphasizes discrepancies in describing levels of oral health when apparently reliable data sources do not meet the study objectives of the investigator.

Introduction

In recent years, the need to properly evaluate research findings has demanded that investigators consider proper sample size selections in their study designs. Dental researchers, especially those involved in population studies are faced with the problem of designing a protocol which will be conducive to statistical significance testing. They must, therefore, have fair estimates of the size of the sample, or samples, required for valid interpretation, since this will often determine not only costs, space, and time requirements, but also whether the study can be successfully undertaken.

This report will follow the same pattern as part I of this series. It will emphasize the lack of reliability of secondary data sources, and will elucidate the resulting difficulties encountered in sample size de-

terminations if unreliable data is utilized. Once again, a real study situation will be used to demonstrate these objectives.

In anticipation of the initiation of a costly and time consuming longitudinal study at an in-residence vocational training center, a preliminary dental survey was completed to provide baseline data to be utilized in designing the mechanics of the future study. Of prime interest in this preliminary investigation was the accumulation of data for the purposes of sample size determination. Another objective was the determination of the reliability of available dental data. If dental studies were to be introduced at a multitude of similar training centers based on the reliability of on-hand data, perhaps pilot and/or full-scale studies could be completed by dental records review, a technique that has proven to be less costly and less time-consuming. However, these investigators were aware of the high risk of unreliable secondary obtained data. Therefore, to evaluate the possibility of (1) using on-hand information recorded on dental records for a large scale study, and (2) to employ information obtained from the dental records to program a study, the following exercise was completed to evaluate reliability of data in a real study situation.

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Methods

To evaluate reliability of dental records information at the study center, two procedures were completed: (1) a dental examination of 20% of the population under investigation, and (2) a documentation of the dental data as recorded from their respective dental records. The population, ranging in age from 16-21 years, totalled approximately 310 young women, at any particular time during the year. The preliminary records review and dental examinations were completed within a two day period, in March, 1971. One dental examiner, who was previously calibrated for reliability in examination techniques, completed all the dental examinations according to specific survey criteria. The index used to clinically assess the dental health profile of the individuals was the DMFT (Decayed, Missing, Filled Tooth) Index. The subjects to be examined for this preliminary study were randomly selected from a roster of the total population. Upon completion of the examinations of those selected, the information on the dental records of those examined was transposed to similar dental survey forms as used in the clinical examinations.

Results

A. Comparison between actual examination data and record review data

There was a mean difference of 4.74 DMFT between the study group (dental records) and control group (actual oral examinations), with the study group presenting an underestimation of dental health status (Table 1). It should be noted that 62% of cases represented differences

of 4 or less DMFT between groups. A mean difference of 3.93 Decayed Teeth was found between the study and control group, once again, the study group being underestimated. Approximately 95% of cases represented differences of 2 or less Missing Teeth between the groups, as a mean difference of 1.61 Missing Teeth was found between the groups (the study group contributing lesser scores). There was a mean difference of 1.45 Filled Teeth between the groups, the study group presenting the lower mean scores. 88% of the cases represented differences of 2 or less Filled Teeth between the groups.

There were statistically significant differences (95% level) between the DMFT Scores for the two groups (Table 1). Comparison of the component scores revealed statistically significant differences between the Decayed Tooth and Missing Tooth scores. The difference between the Filled Tooth component scores was not statistically significant. In all the aforementioned comparisons, the study group presented lesser mean scores.

B. Differences in sample size determinations

The calculation of the sample size required for the future survey could be based on either the actual dental examination data or the records review data. It is at this point, based on the differences recorded between the study and control groups, that significant program design considerations came into play, especially relative to time and cost factors.

The accuracy desired for the anticipated survey was a sampling error of not more than 5% (at the

95% confidence level) in the mean DMFT figures. The sample size to produce this level of accuracy was calculated employing the following formula (there are others that can be employed) :

$$n = 4 \frac{(SD)^2}{(M_{DMF})^2 \left(\frac{x}{100}\right)^2}$$

where, n = sample size

SD = standard deviation (estimate from the pilot study)

M_{DMF} = mean DMF Teeth per subject (estimate from pilot study)

x = percentage sampling error

Therefore, employing the data from the actual dental examinations,

$$n = \frac{4(4.99)^2}{(16.29)^2 \left(\frac{5}{100}\right)^2}$$

$$n = 150$$

If we applied the mean DMFT Scores recorded from the dental records,

$$n = \frac{4(6.93)^2}{(11.96)^2 \left(\frac{5}{100}\right)^2}$$

$$n = 537$$

Therefore, the difference between the two anticipated samples would be 387, or more than two times the real sample required, thereby increasing the time and cost requirements by a factor of three. The procedure described is reliable for descriptive studies.

C. Anticipated differences for experimental utilization

If the investigators were interested in testing effects of the in-

troduction of a specific variable into a protocol for caries experience, there would be the need to consider certain sampling procedures to verify the sample size of two groups. Utilizing the following formula to solve for N or sample size,

$$N = \frac{F^2 v^2 [1 + (1-R)^2]}{R^2}$$

the following assumptions are made,

$$F = t^2 \quad \frac{s}{V_1 = V_2 = \frac{s}{\bar{x}}}$$

$$R = \frac{\bar{x}_1 - \bar{x}_2}{\bar{x}_2}$$

Since dental caries increments are skewed with age, that is, there is no normal distribution, it can be assumed that there is a high coefficient of variation, usually to 100%. We can presume that $\frac{s}{\bar{x}}$ will equal 1,

based on the establishment of two sample means presenting two sample variations which are equal ($V_1 = V_2 = \frac{s}{\bar{x}}$). "t" must define the level of

significance, in advance, and if we are to expect "p" to equal 0.05 or set a level of significance at 95% then the value for "t" for 0.05 is 2. The F ratio values are equal to "t²" or a value of 4. To demonstrate that a real effect occurred between the groups, a 20% difference should be expected, to be considered within the limits for a 95% level of significance. Thus, to demonstrate a real difference between the groups examined, the assumption in this case will be that $R = 0.2$ or 20%

$$N = \frac{(4) (1) [1 + (1-0.2)^2]}{(0.2)^2}$$

$$N = 164$$

The important thing to note from this portion of the exercise is the close similarity between the sample size needs for descriptive and experimental studies. The authors are aware that, for the experimental portion, they can introduce a variation in sample size by altering the expected experimental difference desired. However, the assumptions presumed are consistent with sound dental epidemiologic principles. It should be noted that we have not included sampling techniques involving proportional sampling by probability or prevalence rates in this report. The difficulties associated with sample size determinations, based on disease prevalence estimates, will be dealt with in a forthcoming report.

Discussion

The statistically significant difference between the mean DMFT Scores of the study and control groups was due primarily to an underestimation of the Decayed and Missing Tooth factors. There was also a substantial contribution by the Filled Tooth Component. This difference assumes great importance when the data is utilized in program planning. As demonstrated, there would be a three-fold increase in the size of the sample required for valid interpretation of results at the 95% level of significance. The increase in time and cost factors could suggest a study to be administratively unfeasible. Therefore, it is without hesitation that the authors continue to de-emphasize the usage of secondarily obtained research data. Those experienced in population studies are familiar with the recommendation that sample size estimates should be inflated arbitrarily by 10% to

allow for sampling error, variability, non-respondents and other confounding variables. Therefore, the sample estimate of 150 would more approach the experimental estimate of 164, with an adjusted estimate of 160 subjects.

All too frequently, dental researchers initiate projects without reference to adequate sampling techniques or sample size determinations. We have limited this presentation to sample sizes. Future reports will be devoted specifically toward sampling techniques.

Once again, the lesson to be learned is that preliminary data, or for that matter all data to be analyzed, should be obtained by methods which are carefully spelled out and criteria by which dental examiners, or records reviewers, can be calibrated. The dental researcher must be quite confident of the reliability of the data source, if secondary information is to be used in primary analyses.

It should be pointed out that the results of this study are of value to the researcher and the administrator. The value to the researcher is obvious. For the administrator the cost factors prevail; that is, if smaller populations can furnish descriptive data reliable at the 95% level, the decreased costs could be substantial. It must be noted that data obtained in preliminary surveys can be incorporated as part of the total survey, in most instances. Also, proper pre-sampling could insure the administrator of being the recipient of future reliable data, especially related to the basic sample size of populations under investigation.

Conclusions

1. There was a significant discrepancy between data obtained by actual dental examination as opposed to utilization of apparently reliable dental records at a dental clinic of an in-residence vocational training center.
2. Sample size determinations, using both groups of data separately, indicated a three-

fold discrepancy in size. Utilization of questionable data could reflect unrealistic time and cost factors for study design programs, if sample sizes are overestimated.

3. Small sample sizes, which are statistically unsound, provide unreliable data, which can be detrimental in program planning or evaluation.

TABLE 1

Statistical Comparisons between the Mean DMFT (Decayed, Missing, Filled Tooth) Scores, and the Component Scores of the DMFT Index, as obtained by actual dental examination in contrast to similar dental profiles as interpreted from their respective dental records for 62 randomly selected residents of a vocational training center.

	<i>Mean Decayed</i>	<i>Mean Missing</i>	<i>Mean Filled</i>	<i>Mean DMFT</i>
Records Review	6.16 (± 4.89)*	3.03 (± 3.80)	2.77 (± 3.47)	11.96 (± 6.93)
Examination (Control Group)....	9.54 (± 4.60)	3.41 (± 4.33)	3.32 (± 3.63)	16.29 (± 4.99)

$p^{**} = < 0.05$

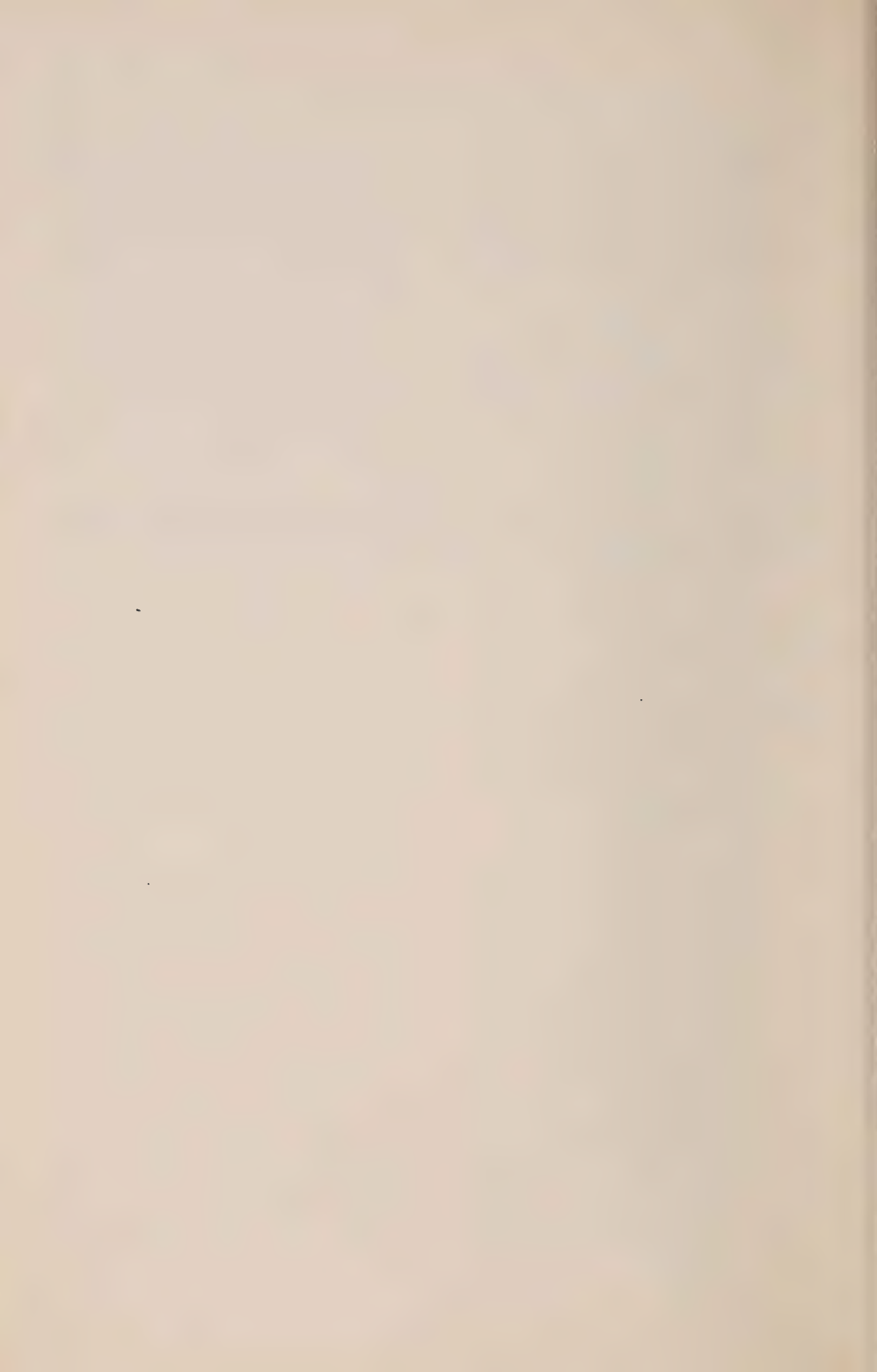
< 0.05

> 0.05

< 0.05

* Standard Deviation of the mean

** "t" test of significance



Dental Education and the Community: A Field Experience

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Nearly all of the American dental schools have established Departments of Community or Social Dentistry in the last five years. One of the major objectives of these departments is to teach dental students new methods of health delivery that will enhance the quality and quantity of services in the community.¹⁻⁴

In its search for more innovative teaching techniques, the Department of Community Dentistry at the University of Maryland has been utilizing extra-mural experiences in each of the four years. The freshman field visit has especially aroused the interest of dental educators and other members of the dental profession. This paper presents a descriptive study of the rationale, objectives, format and evaluation of this first year extra-mural program.

Field Program Rationale

The extra-mural exercise has become one of the most vital educational tools to bridge the gap between theory and reality in the teaching of community health concepts. During the field visit, the dental student uses the community

as a living laboratory for observation and study.

The field visit program is both didactic and clinical. The community is the clinical area for the practical application of Community Dentistry concepts. The program is structured to provide the student with an insight into specific realities of both his world and that of his patients and some knowledge of how his patients function in their own environment. It helps the student identify the people, services and resources involved with meeting patients' health needs.

The University of Maryland's extra-mural program starts as early as the first trimester of the freshman year and continues through every academic year until the fourth year. Experience shows that the greatest impact on the student's critical thinking is made in the early stages of a new educational experience.⁵ This, then, is the rationale for starting the field visit program when the student has hardly become acquainted with the dental school and its faculty. At the time when he is most receptive to new concepts and ideas, the student is made

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aware of the fact that "people", "service", and "community" are dimensions of dentistry as important as treatment of specific diseases of the oral cavity.

Each year's series of field visits is administratively attached to some specific course in the curriculum. Their content and objectives are an integration and expansion of the didactic portion of the course. The field series reinforces the knowledge presented to the student by more conventional methods.⁶ The objectives, structure, and format of each series of community experiences are different from one another but an attempt is made for each successive field experience to have a cumulative effect in broadening the students' knowledge and level of learning and sophistication.

Evaluation of the Field Program

It is significant that the freshman field visit is only one of several field visit programs conducted by the Department of Community Dentistry. Since all the field programs are integrated, there is little attempt to evaluate the influences of the various curriculum segments on a fragmented basis. The freshman experience is not evaluated in isolation from the impact of the entire extra-mural sequence. Therefore, the evaluation presented here is based on the subjective appraisal of the field program by faculty, students and participating field site personnel.

The subjective evaluation quotations presented in this paper are from hundreds of students over a three year period and cover a wide range of subjects. Opinion that the program is beneficial is almost

unanimous. The major criticism of the first year program is that each student is limited to a single field visit and has no reference for comparing experiences.

Objectives of the First Year Field Experience

The freshman field experience is designed to give the student the opportunity to observe, in a community setting, the relationship of dental problems to individuals and social groups and to study some of the factors affecting the distribution of dental disease in a population. It also gives the student an introduction to epidemiology by requiring him to collect and record data from personal interviews.

The broad goals relating directly to the human behavior dimensions of the field experience are:

1. To sensitize the student to the sociological and psychological factors which have an impact on behavior, attitudes and values of people from various socio-cultural groups, with special awareness of the relationships of these to health and illness.
2. To sharpen the perception of the student so that he may develop more social awareness and become a more skilled observer of people, community institutions, and the social environment.
3. To develop knowledge and a theory of behavior which will enable the student to see himself and his patients as part of an overall social system.
4. By better perception, to improve the interaction between the dentist, the patient and community.

The instructional goals⁷ of the field experience are that students should be able:

1. To differentiate the attitudes held by individuals from varying socio-economic and cultural backgrounds towards:
 - a. health and illness
 - b. dental health and dental disease
 - c. dentists
 - d. dentistry
2. To recognize the magnitude of the differences between the living environments and health attitudes in children from backgrounds which are different from their own.
3. To recognize the considerations involved in planning and executing interaction with community agencies and institutions.
4. To recognize that the dentist's concern for health is not limited to his office environment.
5. To recognize the relevance of the biologic-psychologic-sociologic theory to health and illness behavior.

Careful analysis of the first year field project over a three year period has pinpointed the two crucial features which have contributed to its high level of acceptance.

1. The student assumes his professional role for the first time.
2. This is the first contact between the student and a "live" patient.

These factors make the field visit an especially satisfying emotional experience for the freshman dental student. The impact of the trip is

intensified by his apprehension about other parts of the dental curriculum at this time of his education.

In principle, the highly charged, positive emotional reaction helps the student become more receptive to the community dentistry frame of reference. It is a reminder that a "community" and a "world" exist beyond the walls of the dental school. The student's daily concern with meeting current academic demands leaves him little time to think of the community. This exercise, however, "shakes him loose" from his traditional opinions about people from socio-economic groups which are different from his own. Hopefully, it will help him become more open-minded and flexible in his personal and professional attitudes and more accepting of individual differences in people. Often this is the student's first awareness of the idea that innovative and differential approaches to patient care and management may be desirable.

The Field Site

A field site was chosen which had the potential of demonstrating in action the concepts of preventive dentistry and community health. Since intervention for prevention of oral health problems is most effective when initiated with young children, the elementary school children became our target population. The public and private elementary schools became the primary field visit sites. A very practical consideration in using the school system is that by its very size, it is abundant with potential field sites.

The student project performed at the field site is in keeping with

the students limited dental knowledge. Some freshman have their field visit just two weeks after entering dental school. In the field exercise, students screen fifth grade children for the presence of six year molars and conduct interviews with the youngsters to learn about their oral health patterns and attitudes.

The extra-mural experience starts with a two hour orientation session which the faculty, a social scientist and a dentist, utilize to cover the mechanics and objectives of this initial community experience. The sociological determinants of behavior related to health attitudes, health behavior, and dental care is emphasized. Essential information needed for identification of the six year molars is taught. Subsequently, the class of 128 students is divided into groups of approximately eighteen students. The project requires nine hours for each student. On a staggered schedule each group visits a different field site. The schools in the selected field sites are located in diverse socio-economic and cultural areas.

Both students and faculty recognize that the major weakness of the program is the student visits a single field site and does not receive multiple comparable experiences. Curriculum demands and scheduling problems prevent expansion of the program to include a second experience. To compensate, two methods are employed to broaden the impact of the experience. Where appropriate and feasible, an effort is made to utilize the student's own life experiences as the polarization of the field experience. He is exposed to contacts in the community which are the

antithesis of his own background. For example, affluent students are sent to ghetto schools in the inner city; while those from more modest backgrounds see what school life is like in a wealthy private school. In addition, a class summary session is held which allows for the exchange and discussion of feedback from all the field experiences.

The Format

The dental school arranges transportation for the students to and from the visit sites and underwrites the cost of the bus. Not only is this a student convenience, but it insures punctuality at the schools being visited. This is necessary because of an early dismissal time for the school children. The informal student-faculty interaction on the bus trip makes teaching easy and effective en route to and from the field sites. It also gives the staff a chance to "tune in" on students' feelings and reactions, and at times, to focus or channel students' observations in directions that may increase their learning experience.

Even though the same general format governs all the trips, each extra-mural exercise is different. The interaction between the school setting, the school personnel, the children and the dental students gives each trip its own distinct flavor and character. Two dental school faculty members are always present on each field trip to insure that the teaching goals are fulfilled.

When our students arrive at the field site, the school principal spends about thirty minutes with them for orientation. The principal discusses pertinent demogra-

phics of the area; the background and performance of the school children; the quality of the school's faculty; the children's health level; the school's program, facilities, problems and plans; and the effect of environmental influences on the children's learning patterns, attitudes and behavior. Then the students are briefed on the particular fifth grade they visit. Frequently our students observe the class during its routine session. Sometimes the teachers present a health unit in anticipation of the dental students' visit. On rare occasions, we have witnessed a discussion of dentistry geared to the fifth grade level. One of our students, who visited a class having a lesson on parts of a tooth wrote:

"I was fascinated by what the children knew about their teeth. I tried to remember if I had ever learned about the parts of the tooth when I was in elementary school. I'm sure I didn't. I thought it was great, but quite honestly, it had me troubled. I kept wondering how those eleven and twelve year olds in a ghetto area could know more about teeth than I did after four years of college and two weeks in dental school. I was afraid the kids might ask me some questions that I couldn't answer and I was so happy a dentist was there to help us."

The exciting part of the extra-mural experience for the dental students and the youngsters follows the classroom observation when the screening examination begins. Until this point, our students have been passive observers. For many this is "just another field trip". When the interviews on a one-to-one basis begin, our students are transformed into den-

tists and the children become patients. Then things start to happen. Now one can see the value of learning by personal involvement.

Our students work in pairs while doing the dental examinations. The fifth graders are divided into small groups — five to seven depending on the class size. Each group of children is assigned to a pair of student dentists. While one dental student assumes the role of dentist and interviewer, his partner acts as recorder. Prior to the examination for six year molars, the "dentist" tries to establish a rapport with the child to facilitate getting pertinent information. The students alternate from "dentist" to "recorder" to share in the total experience.

In some schools, the students work with the children in cramped corners of small classrooms or in hallways. In other schools with better facilities, they may work in the gymnasium, cafeteria, or health suite. Even this aspect of the extra-mural exercise begins to give the students some first hand experience about how physical facilities, or lack of them, may affect the routines, learning possibilities, and patterns of children.

The student's anxiety about his role and performance as the "dentist" diminishes and his level of self-confidence increases with each succeeding interview with the children. Some of the students' written comments reflect these feelings:

"The relationship established between myself and the children was my first true experience in the realm of dentistry. I actually felt a thorough application of some of my knowledge and a

test of my ability to communicate with the children. They seemed comfortable with me, too. I can now draw upon this experience to remember how important it is to call a child by his name, talk about what may seem relevant to him (such as tooth brush color), and to try to relax him. In this instance, the question about tooth brush color not only served to find out if the child owned a tooth brush, but it also seemed to add a feeling of personal attention."

"In its entirety, I found the field trip a stimulating and valuable experience since it was my first contact with anyone in my capacity as a dentist. It was not merely one of those "look and see" trips. I was actively participating and that seemed to add a new perspective to my dental education."

"This experience may be only a minor part of my life but I feel it will have a lasting impression on me in my role as a dentist. It may be comparable to the lasting impression of fear and pain a dentist had on children during their first visit to his office since this was my first visit with a patient."

When the dental screening and interviews are completed, time is allocated for the dental students and school children to talk together informally. This helps the student to distinguish the differences in reactions to him in his professional role, as opposed to that of him as an individual on an informal basis. Then, with the dental students listening, a discussion is held with the children in a total class session to elicit some feedback of their feeling about the field visit. This uninhibited feedback from the

youngsters gives the students an insight into the factors which influence the children's attitudes toward dentists, the images they have of the dental profession, their patterns of health care and their attitudes about health and illness. The children respond with a frankness that goes far beyond the formal answers that filled the questionnaire blanks during the formal interviews.

A revealing remark by one youngster in a ghetto school clearly reflects his attitudes and feelings about dentists and dentistry. The students learn that many other children from this same socio-economic background share these views:

"These dentists didn't use all those scary tools and hurt me. When I first saw all those dentists today I wanted to hide because I thought they would pull out my teeth and I would look funny like my mom. My mom said if she gets enough money together someday I can get a shining gold front tooth. I'd sure like that."

In a school from a different socio-economic stratum another child said:

"I liked these dentists better than the other dentists I've seen. These dentists were young and could talk with me about baseball and other things that I like."

Comments with still a different emphasis came from many children in another setting where many of the parents were professional people. This child's remark was typical:

"This visit was fun because I liked being able to help these

students learn to be dentists. I think I might want to be a dentist someday too."

Sometimes the children have questions for the dental students. One student wrote:

"The school principal allowed the children to ask the dental students questions about dentistry. This proved to be excruciatingly embarrassing because the questions were thoughtful and intelligent and embraced all of dentistry. Our answers were vague and general because we didn't know much about dentistry. The afternoon was enjoyable and profitable. I learned many facts about people from lower class levels and about how society is trying to improve their position through the children. I gained some valuable knowledge in dealing with children. It seemed most important to show an interest in their likes and dislikes and I think that adult patients will feel and react the same way. The children's health needs and the neglect of these needs were also brought clearly into focus for me. We all felt great and got lots of satisfaction when the principal asked the children at the close of the day if they were still afraid of the dentist and their answer was an unequivocal 'no'."

The visit to the school usually terminates with a final informal session with the principal and the teachers. By this time the dental students are excited and enthusiastic about their day's experiences. They have many questions to ask and many perceptive comments to make about some of the discrepancies that they notice between what may have been pronounced by school officials and what they saw in operation. This is especially true in regard to health services for children.*

Making the extra-mural exercise a mutually beneficial experience for our students and those in the school system is desirable. Unpredictable and unexpected spin-offs have come from this first year extra-mural activity. Letters and conversations with field site personnel indicate their high level of involvement and their satisfaction with participation in the program. As a result of our visits some schools have initiated special class units on health careers; others are strongly impressed by the benefit the children have received from exposure to new people who care enough to spend several hours with them; while others have organized reciprocal visits to the dental school for their classes. It is especially significant that every school used by the University as a field site strongly urges us to return on a continuous basis.

*Students ask why the children report they have never seen a dentist when it was emphasized by the principal and the school dentist that almost all of the children received dental care by referral from the school into a city health department clinic. They also ask if they were correct in concluding that the school dental program is not comprehensively pursued and if the children receive care only when there is an emergency request.

Another student who was more accepting of the information presented by the staff said:

"I was surprised to learn that the school had a dentist who visited one day a week. I didn't know there was such a thing as a Public Health Dentist! This program of seeing all the younger children and gradually acclimating them to dental care may account for the ease with which our own oral examination went."

The stimulation, provocative comments, and questions about many ideas that are new to the students, or that relate to things that shatter some of their previous preconceptions, continue during the trip back to the dental school. The students' passive acceptance of the field visit project, which may sometimes be felt on the drive to the field site, becomes an enthusiastic and voluble response on the return bus trip.

Typical of the many comments are these written by one first year student:

"In summing up my experience, I have to admit I was looking for the worst. I felt at the onset of the trip that time could be better spent studying for my forthcoming Anatomy and Histology exams. What I found was just the opposite. I would like to say that this day has been very memorable for me and will stay with me for a long time. I can see now that there is no equivalent to getting out and meeting the people with whom you may someday be working. A major observation for me concerns the fact that I have always tried to eliminate any and all prejudiced feelings within myself. I still found that I allowed myself to expect a second rate institution because the school was predominantly black. My thoughts are moving toward the possible conclusion that socioeconomic factors are certainly more important in dental health than racial factors. It surprised me that in a school in which the children were 90% black, the child I saw who did not brush her teeth and who had never been to a dentist was a white girl! I think that poor dental

care can be adequately challenged by an excellent early dental health program within capable educational institutions."

After all the field visits and assigned papers are completed, a concluding session for the entire first year class is held. This enables the faculty to pull together the concepts introduced during the orientation session. The students, on the other hand, are anxious to have the opportunity to compare their experiences with those of other students who visit schools in a different milieu. For this summary session, the class is divided into six heterogeneous groups representing all the field sites. The students in each group, under the guidance of a student chairman, discuss their reactions to these varied experiences. These discussions are usually quite broad in scope. Often they range far afield from the individual visits. They may be concerned with other problems in the health professions. The students animatedly express a great deal of concern for the delivery of dental care to patients.

It is interesting to note that the field visit program has done much to activate the social conscience of the dental students. Students of a few years ago, who studied under the traditionally patterned dental curriculum had little knowledge or interest in public health dentistry or the role of the dentist in making dental care available to those in need of treatment.

CONCLUSIONS

This paper presents a description of various aspects of the initial field exercise for freshman students under the aegis of the Department of Community Dentistry

at the University of Maryland, School of Dentistry. From its inception four years ago, this program has been well received by the students and the community. Although this extra-mural experience is only part of the first year course in Community Dentistry, along with orientation lectures and the concluding seminars, it gives the students an exposure to community problems which would be impossible to duplicate in the classroom alone.

Careful analysis of this teaching modality by the faculty has en-

abled them to develop a set of basic principles which are inherent to the successful outcome of this particular teaching approach.

On the basis of the experience described in this paper and the other extra-mural components of our program, we consider the extra-mural exercise to be an exciting and legitimate method of teaching. It serves as an important adjunct to other modes of presentation in dental education programs, and adds a dimension to learning that is not accomplished by other educational approaches.

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Anteroposterior Facial Orthopedics In The Pedodontic Patient

by NORMAN TINANOFF, D.D.S.*

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INTRODUCTION

In the pedodontic patient, the realm of facial orthopedics has been an area of controversy for many years. The term facial orthopedics refers to the movement or inhibition of movement of the bones and joints in the face. Forces used for this purpose are considered heavy forces, that is, over one pound of pressure, as opposed to the light forces used in orthodontics to move teeth. These heavy forces are used to correct basal and anteroposterior jaw malrelationships before maturity of the patient has been reached. It is known that most patients treated by orthodontists have problems involving anteroposterior jaw relationships in which jaw prognathism or retrusion are dominant characteristics. Graber (1969) has stated that two thirds of the patients treated orthodontically have jaw malrelationships with Class II or Class III anteroposterior dysplasia.

To understand facial orthopedics more closely, one must know how the jaws grow. As an overview, the maxillary skeleton increases in all three planes—height, width and depth. This occurs by four methods: (1) replacement of cartilage by bone in the base of the skull at the sphenoccipital and sphenethmoidal junctions, which contrib-

utes to the forward growth of the face; (2) appositional growth on the surface of the bones, contributing to growth in all directions; (3) growth of the nasal cartilaginous septum which provides for downward and forward growth; (4) sutural growth which contributes to downward and forward growth. The mandible, on the other hand, grows primarily from one growth center—the condyle. This structure, covered with cartilage, proliferates in an upward and backward direction, which results in the entire mandible moving downward and forward. This directional growth can be variable and can often change directions from vertical to horizontal; yet, the general tendency of the maxilla and mandible is to grow in the downward and forward direction. Growth of the jaws often follows the general growth trends of the rest of the body, that is, constant incremental growth until the pubertal growth spurt at 10 to 12 years for girls and 12 to 17 years for boys. After this period growth essentially ceases.

The purpose of facial orthopedics is to control, retard, or accelerate growth in a particular portion of the jaws so that there will be a greater balance and harmony. In this way, future orthodontic treatment, if necessary, will have a bet-

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ter prognosis because jaw relationships will be improved. This review will attempt to explore several aspects of facial orthopedics: rationale for early treatment, physiologic basis for orthopedic movement, clinical Class III treatment, and clinical Class II treatment. Treatment of cleft palates by orthopedics, palatal expansion and treatment of the open bite will not be covered because the emphasis of this paper will be on anteroposterior corrections.

REVIEW OF THE LITERATURE

Edward H. Angle, in his *Malocclusion of the Teeth*, 1907, stated: "It becomes an axiom, that the proper time to begin treatment is as near the beginning of the variation from normal in the process of development of the dental arches as possible." In the primary dentition it is not difficult to recognize early disharmonies between the mandible and the maxilla. A four year old patient whose occlusion shows the maxillary canine a half cusp forward from its normal position presents strong evidence of a developing Class II (West, 1969). There is little question about the Class II relationship in those patients in whom the canine or primary molars are a full tooth forward from their normal relationship. Evaluation of Class III malocclusions by the same method is possible, although the uncertainty of mandibular growth makes prediction more unreliable (West, 1969). Hahn (1955) stated that clinical evidence has shown that Class II Division I and Class III malocclusions have no reasonable possibility of self-improvement or self-correction and should be treat-

ed in the primary or mixed dentition.

The literature describes reasons why these early malocclusions should be intercepted. West, in 1969, observed that correcting the abnormal relationship of the anterior teeth early will change the dentoalveolar environment so that the segments have an opportunity to reach growth potential. Along this same line, Forrest (1963) stated, "How many of the cases which at a later date are diagnosed as true Class III malocclusions were really at one time in the patient's growth period undetected simple pseudo-Class III malocclusions". The concept that structural imbalance, as well as muscular imbalance, will increase, causing an exaggeration of the original malocclusion, is well documented (Hahn, 1955; Dewel, 1964; Hausser, 1969).

An abnormal anteroposterior bone relationship not corrected in the primary or mixed dentition becomes stabilized in the permanent dentition and difficult to treat. Graber (1969) stated that establishment of normal neuromuscular physiology by moving teeth alone at this time can only be partially successful. There is clinical evidence that the resulting disharmonies often become so fixed that later treatment at its best cannot entirely overcome the damage that has progressed over the years (Hahn, 1955; Kloeckner, 1953; West, 1969).

Often, treatment in the pedodontic patient takes long periods of time with extended retention to avoid recurrence. Benard and Barakat (1970) are of the opinion that most children cease to cooperate fully after treatment has continued

for approximately two years. Therefore, they recommend that treatment should not be initiated much before completion of the permanent dentition except in very special circumstances, when a delay may cause a deterioration. This same philosophy has been purported by Hahn (1955), who felt that lack of patient management in the young age groups is sufficient to warrant postponement of treatment until the child has arrived at an age when cooperation will be improved.

Correction of a prognathic skeletal Class III mandible has always been a difficult task. Through orthopedics it is felt that transmission of heavy forces to the chin by means of a chin cap anchored to the head might prevent, retard, or redirect growth of the mandible before its maturation. One hypothesis for this type of therapy is that, by exerting upward and backward pressure on the mandible, the pressure is transmitted to the condylar cartilage, which in turn inhibits proliferation.

Theoretically, we see areas of disagreement with this philosophy. Wolf, in 1870, believed that stresses upon bone were responsible for the stimulation of bone (Evans, 1966). We see many situations which reinforce the Wolf Law. Weinmann and Sicher (1955) stated that, within limits of tolerance, an increase in normal force of pressure or tension leads to formation of new bone. Examples of this are found in athletes, who demonstrate considerably heavier bony frameworks because of the extra tension on their bones (Guyton, 1971). If stress beyond physiologic response is applied, we see another mechanism.

Gelbke, using wire loops placed through the knee joint of dogs in 1951, obtained a very high degree of continuous pressure. He found evidence that the inhibition of cartilage and consequent cessation of longitudinal growth took place. It is interesting to note that when this wire was cut, relieving the pressure, the femur resumed its longitudinal growth. Eight weeks after the wire was cut the animal was sacrificed, and it was observed that there was hardly any change in the epiphyseal plate.

Extrapolating from these studies, it would be evident that physiologic mechanical stress placed on the condylar cartilage would have the effect of proliferation of the condyle rather than retardation. However, the condylar cartilage has a unique growth mechanism different from epiphyseal plates. Growth at the condyle is appositional growth rather than interstitial, as in other growth centers (Weinmann and Sicher, 1955). Articular cartilage of other bones lacks the connective tissue covering, found in the cartilage of the condyle, which allows for appositional growth. This appositional growth is dependent on the vitality of the connective tissue covering the cartilage, and it may well be that undue pressure upon the connective tissue decreases or prevents its contribution to the growth of the cartilage (Weinmann and Sicher, 1955). Connective tissue is, in contrast to cartilage, not well adapted to resist pressure.

Baume and Derichsweiler (1961) also contributed to the knowledge of the differences between condylar cartilage and epiphyseal cartilage. Their material consisted of three

female rhesus monkeys between 44 and 50 months of age, which were treated with a splint similar to the monobloc so that their mandibles were in a forward position. After a $2\frac{1}{2}$ to $4\frac{1}{2}$ month experimental period in which the condylar joint was x-rayed, stained vitally, and analyzed histologically, they concluded that the condylar cartilage responded most actively to functional therapy. Other observations were that: (1) growth cartilage of the mandible reacts differently to mechanical stimuli than do the epiphyses of long bones; (2) histologic structure of condylar cartilage is different from that of articular and epiphyseal cartilage in that condylar cartilage is covered by perichondrium; (3) while epiphyseal plates grow interstitially, condylar cartilage accrues by peripheral apposition; (4) maturation never occurs in the condyle, as it does in epiphyseal plates.

In addition to simple retardation of the condylar cartilage, other authors observed changes in the position of the condyle. Breitenner (1940) showed change in form and position of the head of the condyle in monkeys with Class II elastics. Opposite changes were seen when Class III elastics were used. Janzen and Bluher (1965) observed in four monkeys, fitted with headcaps and Kirshner wires through the body of the mandible to produce traction, that there was a disturbance of normal downward and forward development of the dentofacial complex. Histologically, they saw resorption of the posterior surface of the condyles and posterior wall of the glenoid fossa, and apposition at the anterior surface of the condyles. There was no indication of inflammation or de-

generative change. Joho (1968) treated four monkeys with gold splints that forced the mandible into a forward position. He recorded an increase in length two times that of the control animals. After the appliance was removed, the dental changes relapsed markedly while the skeletal relapse was negligible.

A human infant with Pierre Robins syndrome of micrognathia was treated orthopedically by Baume, Haupl, Stellnach (1959). A traction device of 100 grams was used in alternate periods of two hours traction and two hours relaxation. The child died of other causes at age nine months after normal jaw relationship was established. Histologic study revealed that the condylar head showed growth activity in the vertical and horizontal directions exceeding the normal rate, with no evidence of traumatic injury. Ricketts (1960) also confirms, through histologic study, that orthopedic forces affect growth of the mandibular condyle.

The chin cap has been used occasionally in humans to inhibit the skeletal Class III tendency. The first important historical reference relative to the chin cap was made by Joseph Fox in 1803, when he applied it in an attempt to correct mandibular protrusion. Later, in 1879, G. S. Allan attributed success of the chin cap to a remodelling of the structures of the temporomandibular articulation (Weinberger, 1926). With the turn of the century and the advent of intermaxillary elastics, the appliance appears to have lost favor (Armstrong, 1961). In American orthodontic texts today the chin cap receives scant attention.

Some clinical studies, however, have been recently published. Armstrong (1961), using 100 children between the ages of three and twelve with skeletal Class III occlusion, studied the effects of the chin cap. He reported results which indicated that the control group showed no improvement, whereas 40% of the treated cases did. Thilander (1965) in a careful study used 45 subjects (20 males and 25 females) with true Class III occlusion. The patients were treated with chin cap tractions for one to six years and the total follow up treatment lasted five to seven years. A good response was shown in 14 children, fair in 12, poor in 6, and relapse in 12 others. Comparing his successes to his failures, Thilander noted that the favorable cases displayed inclination of the teeth, permitting a lingual tipping of the lower incisor and a labial tipping of the upper incisor. He observed that treatment should be started early and that it should be continued until good vertical overlap and good cuspal relation are established. Vernescu-Leheni (1968) reports that the Class III relationship is found in 2-3% of preschool children, and he confirms that treatment should be initiated at its incipient stages.

Orthopedic force against the maxilla to correct Class II basal malrelationships in the primary and mixed dentition is also used. Ricketts (1960) stated that vigorous retraction force on the maxillary teeth, particularly parallel to the axes of the roots, appears to prevent forward growth and even cause the maxilla to grow downward and backward. Graber et al. (1967) pointed out that force beyond the threshold of tooth moving range in the maxilla will prob-

ably affect the maxillary base itself. The appliance used to produce this pressure has been the conventional Kloehe-type cervical anchorage assembly with the force of 400-800 gm applied to the basal bone by means of the teeth, which serve as a handle. Graber (1969) has recently proposed that ideally it would be preferred to apply direct pressure to the maxilla rather than indirect pressure through just the two molars. Graber has reported construction of a plastic appliance which covers the maxillary alveolar bone as well as the maxillary anterior teeth and is connected to the cervical appliance. He has found, however, that this type of appliance causes irritation and more patient discomfort. As an alternative, he feels that the orthopedic force should be directed against all of the maxillary teeth by banding and splinting.

It is thought that this method of therapy actually redirects the growth of the maxilla rather than inhibits its growth (Reitan, 1969). Moss (1958), using skulls of 65 artificially deformed North and South American Indians, observed greater increments of growth in certain areas to compensate for specific external forces. These cranial deformations brought about a redirection of the vectors or normal neurocranial growth. Moss concluded that growth cannot be changed, but only redirected.

Graber (1955), in a clinical study of fourteen cases of Class II discrepancies which he treated in the primary dentition with head gear, showed that eleven of the fourteen had anteroposterior basal adjustments. He noted, however, that the general response to the head

gear was slow. He has found greater success when the cases are treated in the puberal growth spurt. In 1957 West reported on his treatment of eighteen Class II Division 1 malocclusion cases whom he started treating between the ages of three and four and one half. These cases were treated at this age because of the severity of their discrepancy. Using conventional maxillary extraoral traction, West was surprised at his results. He observed distal movement of point A as well as distal movement of the teeth. He concluded that, rather than retardation or slowing of growth, there seemed to be distal movement of the maxilla. Wieslander (1963) performed an investigation on 30 Class II patients treated with Kloehn-type cervical head gear attached to the maxillary first molars. He compared this group with an equal number of untreated children who were carefully matched to the first group. The comparisons were made by cephalometric analysis. It was noted that the head gear had an influence on maxillary growth. The results observed were: posterior change in the position of the pterygomaxillary fissure; tipping of the anterior part of the palatal plane downward; and clockwise rotation of the sphenoid bone with alteration of facial growth.

King (1968), looking in retrospect at Class II cases he treated in the mixed dentition, concluded that only simple Class II cases involving anterior positioning of the maxillary alveolar process should be treated in the mixed dentition. Cases involving retrognathism, obtuse gonial angle with a steep mandibular plane, relatively great anterior facial height, or severe maxillary protrusion do not re-

spond well to therapy in the mixed dentition and are often subject to relapse.

DISCUSSION

Facial orthopedics, like many treatment modes, has its advocates and opponents. With changing times and increased knowledge, there is often a swing of the pendulum toward greater acceptance or rejection of such specific treatment patterns. Orthopedic force to change the configuration of the face was reportedly used for a time before 1903. Since then, there has been little report of its usage in the United States. The European schools of orthodontics, however, have been using what they call functional orthopedics to change anteroposterior jaw relations since around 1940. Recently, through the stimulus of T. M. Graber, there seems to be a resurgence of the practice of jaw orthopedics to correct facial dysplasia. There is no doubt that anteroposterior basal discrepancies are a significant problem. It is believed that two thirds of the patients treated by orthodontists exhibit Class II or Class III dysplasias. Orthodontists, using light forces, have been frustrated over the years in their attempt to change these patterns. They have generally been able to evoke changes in tooth position only. However, stability of orthodontic results requires a balance of the facial musculature, tongue position, basal structures to the denture and a harmonious functional relationship of teeth. Only through a careful analysis of the rationale and the treatment results can one see if a mode of treatment such as force on bones and joints has its place in the armamentarium for correcting jaw malrelationships.

There have been many conflicting theories over the years about the effect of pressure on the growth of the mandibular condyle. From the literature we see that the theory of the influence of orthopedic pressure on the mandible has evolved from that of no effect on growth, through a retardation of growth, to a redirection of growth. It is, however, conclusive that the mandibular condyle possesses unique tissues that enable it to act differently from other areas of the body. It is believed that the condyle can be affected by orthopedic pressures, but the mechanisms might need more clarification. Several different mechanisms or a combination of mechanisms could have an effect: (1) pressure causing a redirection of growth of the condyle; (2) pressure changing the position of the glenoid fossa; (3) pressure causing a retardation of the downward and forward growth of the condyle. It is felt that additional studies might be useful to further explain this area.

In contrast to the animal studies, the literature reports only mildly favorable responses to the use of the chin cap in humans to retard or redirect mandibular growth. One report shows an improvement in 40% of the cases when a chin cap was used. Another cites good responses in 14 children, fair in 12, poor in 6 and relapse in 12 others. The reason for this difference is not readily apparent. Phylogenetic differences, cooperation differences, or differences in mechanics may play a role. Some important clinical guides can be gathered from the studies. For best results it is probably necessary to initiate therapy at the initial stages of malocclusion. It is now thought that the pressure

should be from three to four pounds for ten to twelve hours a day. The overbite should be deep to permit a reliable vertical overlap and to lessen the chance for relapse.

Thus, one is faced with the question—Can the chin cap be used to prevent skeletal Class III occlusion in young patients? At present the answer does not seem clear. There is a good physiologic basis and laboratory experience to indicate that orthopedic forces will be useful in these cases. However, dramatic results might not be expected practically. Treatment might have to be prolonged and repeated if relapse is evident. Best clinical success can be suspected in patients who demonstrate deep overbite.

Orthopedic forces on the maxilla can have a significant effect on growth and development. Here the physiologic mechanism for change seems to be primarily redirection of growth rather than an inhibition of the growth centers. In the maxilla we are dealing with a complex growth mechanism which draws its growth potential from at least four different sources. Because of this complexity, it is not readily apparent where orthopedic forces are being utilized.

Clinically we see successful results, yet not as dramatic as would be found if treatment were performed in the permanent dentition during growth spurts. Graber recommends that pressure of one to two pounds be distributed uniformly in the maxillary dentition so that the teeth are not affected but act just as a handle to transmit the force. Cervical anchorage, as well as occipital anchorage, seems to be effective. It is probable that

with heavy increments of force the direction of force application is less important than with light forces. As with the Class III cases, better results might be attained with careful selection of cases. King suggested that Class II cases with simple anterior positioning of the maxillary alveolar process would be most successful.

An important aspect of the feasibility of orthopedic treatment is the factor of age. It is not difficult to recognize early disharmonies between the mandible and maxilla clinically. Family histories showing tendencies for disharmonies are also useful. There is abundant clinical evidence that Class II and Class III malocclusions with more than one half cusp disharmony have little chance of catching up with continued growth and maturation. Further, there is general agreement that if these malrelationships are left untreated, they become progressively exaggerated because of muscle and functional imbalances. Again, these disharmonies become so fixed that later treatment, at its best, cannot entirely overcome the damage that has been progressing through the years. With an abnormal antero-posterior bone relationship in the permanent dentition, efforts to establish normal neuromuscular physiology by moving teeth alone can only be partially successful.

As we have seen, however, there are valid disadvantages in early treatment. Many orthodontists

feel that children at an early age will not be mature enough to cooperate with therapy. The response to treatment at this time will be slow because there is less growth during this period. The mandible grows an average of 3 mm. annually in the juvenile period with times of marked fluctuation. Later, in the puberal growth spurt, the average growth will be about 5 mm. Whether the theory of treatment is growth inhibition or redirection, we can see that our efforts will take much longer. It is often necessary that the appliance be worn for two to four years, and sometimes longer if retention is required to avoid recurrence. More expedient orthodontic successes are produced when treatment is carried out in the growth spurt.

Even with the above contraindications, this author agrees with Angle's opinion that treatment of basal disharmonies should be attempted at the beginning of the variation from normal. In this way, interception of structural and muscular imbalances may create the best environment for proper jaw development. Whereas it has been shown that non-corrected jaw relationships often lead to exaggerated distortion as oppositional bone growth becomes more prominent in the late mixed dentition and in the puberal growth spurt. If patient management becomes a factor, treatment can be terminated without much sacrifice and resumed later in the permanent dentition.

SUMMARY

1. Facial orthopedics for correction of anteroposterior jaw discrepancies has been surveyed.
2. There seems to be a recent resurgence of this treatment mode for correction of skeletal Class III and Class II disharmonies.
3. There is definite evidence that orthopedic forces can affect the growth and development of the mandible; yet it is not clear, at this time, by what mechanism this takes place.
4. Clinical studies show mildly favorable results in the use of the chin cap for correcting skeletal Class III dysplasias.
5. Orthopedic forces on the maxilla act primarily by redirecting growth.
6. Clinically, it is found that orthopedic forces are successful in redirecting growth of the maxilla in the primary and mixed dentition; yet results are more dramatic when treatment is carried out during the pubertal growth spurt.
7. There are advantages and disadvantages to initiation of orthopedic therapy with the pedodontic patient, but it is felt that there are significant treatment advantages to warrant commencement of this procedure as soon as basal discrepancies become apparent.

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Application of Neuromuscular Function to Determine Occlusion and Rest by Visualizing Masticatory Muscle Potentials

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SUMMARY

Summary

It is apparent that the neuromuscular systems play the dominant role in mastication. The objective of providing a healthy oral environment involves developing an occlusion which will induce minimal stress that is within the patient's normal tolerance levels. Optimum occlusion denotes the most physiologic occlusion. The introduction of electromyography to record masticatory muscle potential has greatly enhanced our insight into the role of neuromuscular systems. The technique of myogram recordings may be utilized in the determination of rest position, and in the study of movements in the horizontal and vertical planes starting from and ending in the rest position.

Electromyographic analysis may be used to detect aberrant occlusal patterns due to (1) abnormal conditions of neuromuscular origin and (2) changes of individual tooth position.

This on-going investigation, in addition to determining physiological rest position by EMG visualization of the masseters and

the temporalis (the elevators) and the hyoid-digastric complex (depressors), includes also horizontal mandibular movements (right and left lateral) made from the rest position.

INTRODUCTION

The determination of the optimum physiologic relationship between the maxilla and the mandible by means of the usual clinical methods may terminate in either non-conclusive end-results or failure. These results are often due to obstructions or irritations that may have been introduced into the normal occlusal pattern. In such cases, the occlusal pathology may be difficult to detect due to the patient's volitional neuromuscular response and adaptive capacity. In such individuals, electromyography can be an adjunct in determining the true position of the mandible in the horizontal plane.

In clinical prosthodontics, it is imperative that correct maxillo-mandibular relation be determined and the necessary interocclusal distance be accurately established so that the muscles can function physiologically with maximum efficiency.

THE NEUROMUSCULAR SYSTEMS

Three basic biologic or tissue systems are vitally concerned with maintaining a functionally harmonious relationship of the mandible with the maxilla: —the temporomandibular joint components, the teeth, and the neuromuscular systems of mastication. These systems, including the mandibular reflexes, jaw-opening, jaw closing and jaw jerk (Kawamura, 1964) exert control by the sensory input from muscle proprioceptors, joint and ligament mechanoreceptors, oro-facial, lingual, gingival and pharyngeal tactile, pressure and pain receptors. Stimulation of these receptors results in reflex motor responses of mandibular, facial and cervical muscles in a complex pattern of synergism and antagonism varied by latency, thresholds, differential unit function and sensory feedback. Facilitation and inhibition of these systems are further modified by higher center discharge from both the facial and jaw (Kawamura and Takata, 1971) (Sumino, 1971) motor cortex and the reticular activating system (Goldberg, 1971). The basic unit of a neuromuscular system is the motor unit, consisting of one motoneuron innervating a varied number of muscle fibers — ten to fifteen for a fast muscle, and fifty to three hundred or more for slower response muscles.

Activity of these neuromuscular systems can be adversely stimulated by a dental restoration that does not conform to the normal functioning occlusal pattern. First the restoration will be pounded by resultant muscle action from an abnormal sensory input. Eventually the alteration of the func-

tional occlusal pattern may loosen the restored tooth. This is an example of the physiologic struggle for homeostasis, the state of dynamic equilibrium (Perry and Harris, 1954).

Although the neural control of the masticatory systems is largely reflex, fronto-temporal cortex and amygdaloid — hypothalamic areas are involved in mastication, the former in jaw opening and the latter in jaw closing and tooth contact (Kawamura, 1968). The reticular activating system, as well as other sub-cortical centers, are associated with motivational and volitional jaw movement. (See Fig. 1). Both monosynaptic and polysynaptic reflexes have been demonstrated in the sensory feedback system from stomatognathic structures to the jaw muscles. The monosynaptic consists of afferent and efferent neurons, and the polysynaptic includes interneurons connecting the afferent and efferent limbs through the trigeminal nu-

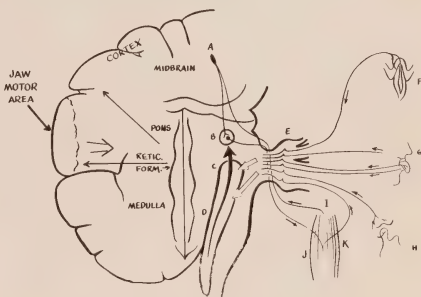


Fig. 1

- A, B, C, D — Trigeminal Nuclei
- E — Gasserian ganglion
- F, G, H — Peripheral Receptors from Teeth, Orofacial and TMJ
- I, J, K — Muscle, Stretch and Fascia Receptors.

clei: the mesencephalic, main sensory, motor and descending spinal.

Since the introduction of electromyography into dental research by Moyers (Moyers, 1950) more than twenty years ago, the normal specific function of each of the jaw muscles has been demonstrated. The changes in muscle potential produced during the complex reciprocal interrelationship to achieve the dynamic equilibrium of normal function have demonstrated the concept of normal muscle participation in jaw movements. An EMG study of one interrelationship between the occurrence of tooth contacts and electromyographic activity during mastication in habitual occlusion and after the insertion of balancing side cuspal interferences (Schaerer, Stallard and Zander, 1967) has been done. The conclusions arrived at by these investigations indicate that tooth contacts are regulated by the reflex mechanisms controlling mandibular movement.

Electromyography has also been utilized to study the electrical activity of the elevator muscles during mastication by patients with complete removable dentures (Michman and Langer, 1968). The recording of muscle activity provides a valuable method for determining the patient's adjustment to new dentures. The complexities of the reciprocal innervation, pathways and higher center controls in the delicate interplay of the masticatory apparatus pose many unanswered questions. With this in mind, members of both Restorative Dentistry and Physiology join forces to apply the experimental techniques in a clinical study.

Electrographic signals are presently being determined during

mandibular positions of physiologic rest, contact and intercuspal occlusion, and masticatory movement. Purely reflex movement may be achieved in future investigations by external stimulation of the jaw muscles, thus by-passing the cortical or volitional neuromuscular system.

ELECTROMYOGRAPH RECORDINGS

Previous investigations in this laboratory utilized 9mm. silver disc surface bipolar electrodes applied to the masseters, the anterior and posterior temporalis and the hyoid-digastric complex on a total of 116 student subjects. The vertical intermaxillo-mandibular distance (VIMMD) was recorded simultaneously with the muscle potentials (EMG) on a Grass polygraph on 16 of the subjects. Techniques, controls and average values were established and reported (Staling and Buxbaum, 1969). In the present investigation the EMG is being monitored on a cathode ray oscilloscope (CRO) from bilateral masseters and temporalis. The additional diagnostic aid of hearing the muscle potentials simultaneously with seeing the EMG is provided by an audio-monitor connected to the CRO output. The polygraph records both the "raw" or direct EMG and the integrated signal, the latter giving a total-area under-the-curve quantitation in millivolt per second (Mv/sec).

In Figure 2 the calibration polygraph record demonstrates the basis for quantitation of EMG and vertical interocclusal distance, recorded on the top channel. Fig. 3 demonstrates masticatory activity when chewing hard food, and Fig.

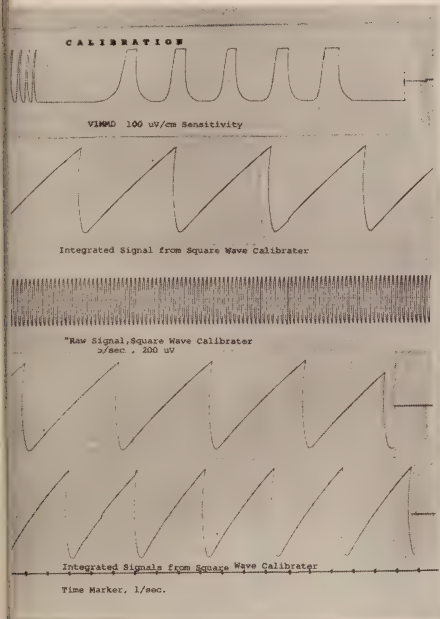


Fig. 2

Calibration for VIMMD in mm and Muscle Potential in mv/sec.

4, the potential produced during drinking and swallowing. It is apparent from Figures 3 and 4 that bursts of muscle potential are associated with increased vertical interocclusal space. Fig. 5 shows the small but consistent and measurable increase in muscle potential when changing the mandible position from physiologic rest to contact occlusion. The VIMMD values range from 0.4 to 4.6 mm. with an average of 2.8 mm. Fig. 6 demonstrates a comparison between these two positions as monitored on the CRO, picking up from the power muscle, the masseters, with occlusal contact on the two lower traces,

and rest on the two upper channels.

Electrodes are applied quickly, easily and painlessly to skin areas over the muscle. In Fig. 7,* note electrodes on the masseter and temporalis, with potentials on the CRO trace indicating a left-sided chewer. The audio - monitor (mounted on the CRO) literally makes it possible to determine the position producing the minimal amount of potential, i.e., the rest position, without seeing either the patient or the record. The CRO trace in Fig. 8 is recorded from a habitual right-sided chewer.

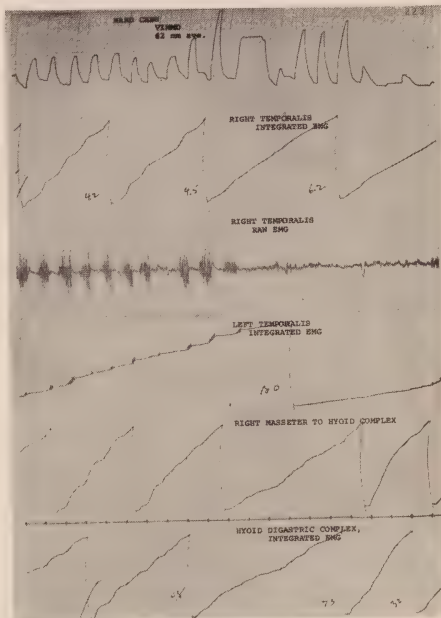


Fig. 3

Bilateral Temporalis, Hyoid-Digastric and Rt. Masseter Raw and Integrated EMG with VIMMD Recorded During Chewing Raw Carrots.

* Author's appreciation is expressed to the patient subject, E. Roth, as well as to photographer R. Elliott and artist J. Gadd, of Educational and Instructional Resources, for their invaluable aid.

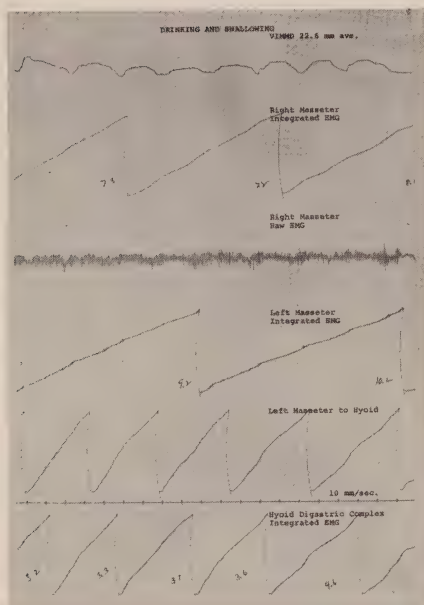


Fig. 4

Bilateral Masseters and Hyoid-Digastric Complex Raw and Integrated EMG with VIMMD Recorded During Drinking and Swallowing.

DISCUSSION

Electromyography clearly demonstrates characteristics of muscle activity that may be utilized clinically as follows:

1. *Physiologic rest position of the mandible.* For normal function within the patient's adaptation tolerances, all muscle tissue requires non-functioning, or resting time. Therapy or restorations resulting in mandibular positions that do not allow a periodic return to resting status for jaw musculature lead to fatigue, and eventually maladaptation problems, pain and tooth pathology. The rest posi-

tion is stable throughout life, and is not influenced by the presence or absence of dentition (Thompson, 1954). VIMMD (the interocclusal space in rest position) changes as a result of tooth loss, occlusal wear and dental therapy. Using contact occlusion as zero VIMMD, we previously reported this range as 1.5 to 2.8 mm. in 16 young normal adults (Staling and Buxbaum, 1969) determined simultaneously with EMG which yields an average value of 9.5 mv/sec decrease from occlusal contact position to physiologic rest. Muscle activity visualization is the most accurate and probably the only tech-

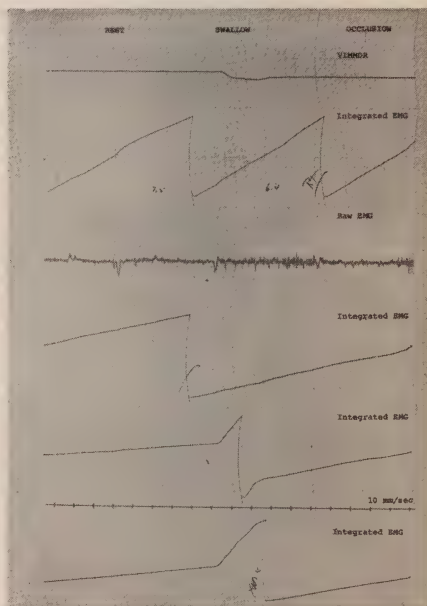


Fig. 5

Bilateral Temporalis, Hyoid-Digastric and Rt. Masseter Raw and Integrated EMG with VIMMD Recorded During Rest and Contact Occlusion.

nique for determination of the true physiologic rest position. Rest position of the mandible is invariably indicated by minimal production of muscle potential, and is reproducible by myogram recording.

2. *Interocclusal space and tooth contact.* Normal interocclusal space must be retained when restoring dental structures, and not obstructed by the vertical height of restorations. Opinion varies as to the functional importance of tooth contacts (Jankelson, Hoffman, and Hendron, 1963) during mastication. Schaerer et al, (1967) claim that masticatory mechanisms are influenced by pressure and tactile receptors during mastication irrespective of the maxillo-mandibular relationship. EMG is a valuable adjunct for accurate identification of these latencies and thresholds, as of all dynamic aspects of the total stomatognathic system.

3. *Time relationship of masticatory muscle action.* The temporalis muscles which move the mandible, show prior activity to the masseters, the power muscles, on EMG recording. Both frequency and amplitude increase with hard chewing as compared to soft food mastication, and demonstrate higher potential with greater tooth contact. (Cadenat, Joniot, Lodter, and Gabreil-Robez, 1968). Electrical activity precedes the mechanical, both at the beginning and end of mastication. Clinically some malocclusion cases manifest electrical activity in the masseters prior to activity in the temporalis. Under the stress of occlusal dishar-

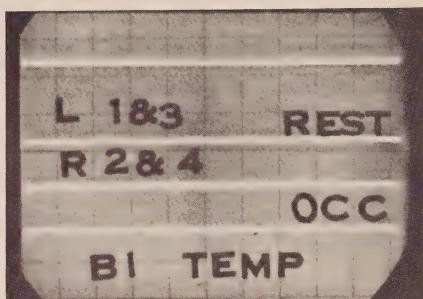


Fig. 6

Oscilloscope Trace of Bilateral Temporalis EMG During Contact Occlusion (Lower) and Rest (Upper).

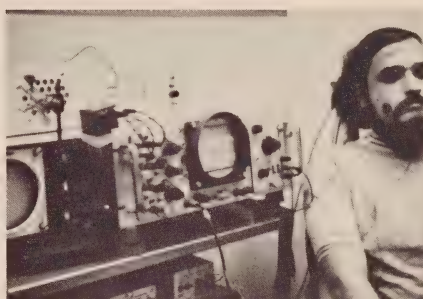


Fig. 7

Subject Recording Bilateral EMG On Oscilloscope, Left on Lower Channel.

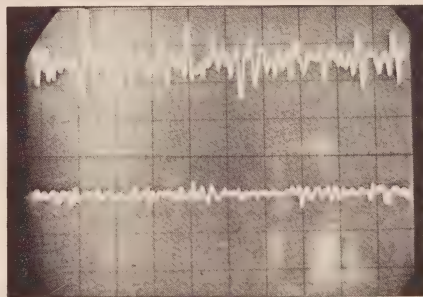


Fig. 8

Oscilloscope Trace of Bilateral EMG During Chewing, Right on Upper Channel.

mony, bilateral temporal and masseter muscles reach maximal activity asynchronously.

These three factors, specific muscle action, interocclusal space with tooth contact and rest position of the mandible, when considered as detailed above, may be applied as adjunct clinical aids. Visualization of the muscle potentials provides

information otherwise unobtainable, that helps the practitioner in restoring normal masticatory function for the problem patient.

Since this is a pilot study report, more data from patient runs are not available at this time. Acquisition of data from problem clinical cases is the goal of the investigation now in progress.

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The Rate of Weight Gain of the Mongolian Gerbil

(Meriones unguiculatus)

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The Rate of Weight Gain of the Mongolian Gerbil

(*Meriones unguiculatus*)

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The Mongolian gerbil, *Meriones unguiculatus*, a member of the rodent family, is indigenous to Eastern Mongolia and parts of China (4). Gerbils are born with hair (as evidenced under the microscope) their eyes are closed and remain unopened for the next sixteen to eighteen days. The newborn gerbil possesses the righting reflex, that is when placed on its back it attempts to attain the normal quadruped position. Interestingly, the pups may be handled by individuals to whom the gerbils are unaccustomed without eliciting adverse reactions from either parent.

In the past decade this species has been increasingly utilized in biological research, but information concerning many of its characteristics is lacking. The age related body weights of gerbils have already been reported (1, 2, 3, 4), but data concerning the day by day increase in body weights of very young gerbils have not been investigated. The purpose of this communication is to furnish that information.

PROCEDURE

Gerbils were housed, two per large, clear plastic cage, about 70°F in a room artificially lit from 8 A.M. to 5 P.M. All gerbils had access to water

and Purina Rat Chow *ad libitum*. This diet was supplemented occasionally by lettuce and sunflower seeds. Cages were checked each weekday and dates of birth were recorded. Pups were weighed daily, five days per week, and immediately returned to their respective cages. Forty two pups, from eight separate litters, were used, of which thirty four survived the duration of the experiment. The available body weights were pooled for each day, and the mean body weight and standard deviations were computed (Fig. 1).

DISCUSSION

The data presented here are in agreement with those of Schwentker, who recorded the weights at birth, ten days and twenty days of age (4), as well as with the results of Nakai, Nimura, Tamura, Shimizu and Nishimura (3) and Marston and Chang (2), who reported the weights at birth and twenty days of age.

The weights of the pups increased steadily (Fig. 1) during the time period studied, and the average weight gain was 0.5g/ day. The greatest increase, as a function of an individual's own body weight occurred in the first few days of post-natal life. Interestingly, the weights of individual pups were independent both of litter size and litter mates.

SUMMARY

The weights of new born gerbils and the age related weights of very young gerbils were studied. It was

found that the average daily increase in weight was 0.5g for the first twenty days of postnatal life.

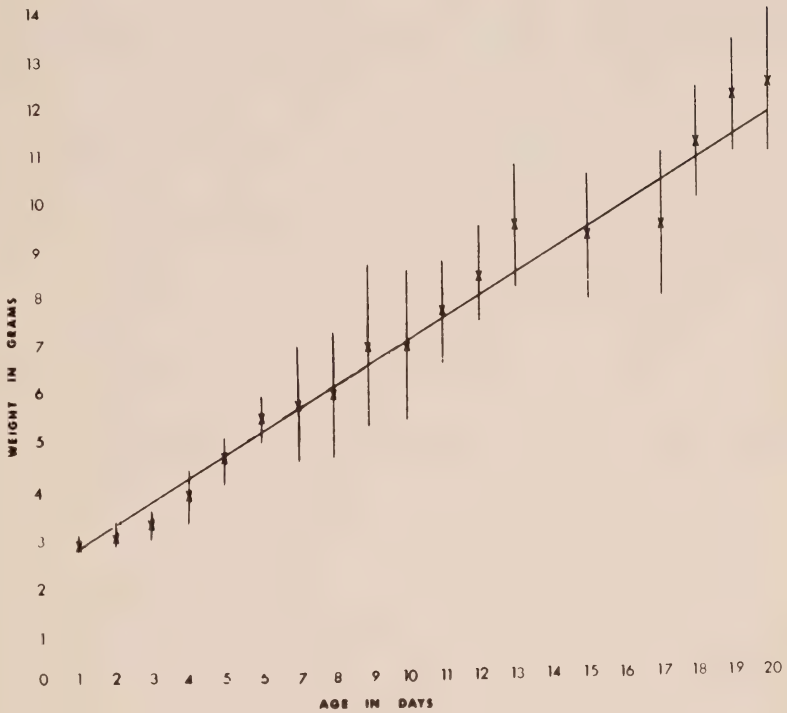


Figure 1. Graph of the age related weight increase of very young gerbils. The vertical bars indicate the standard deviations.

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**Evaluation of Drug Utilization by
Dental Patients. I. Drugs
Prescribed in a Dental Clinic
for Home Use.**

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Summary

Drug utilization in a dental clinic patient population has been evaluated over a four month period according to the type of drugs prescribed, the drug prescribers and the patients receiving medication. Four therapeutic categories consisting of narcotic analgesics, penicillin antibiotics, non-narcotic analgesics and non-penicillin antibiotics represented 97% of all medications prescribed. The drug product most frequently prescribed was penicillin V (21%) and the trade name and strength most frequently written was Darvon Compound-65 (18.3%). Five clinic specialties prescribed all medications and ranked as follows: oral surgery 63.0%, periodontics 19.0%, oral diagnosis 10.8%, endodontics 5.6% and restorative dentistry 1.6%.

The departments of oral surgery and periodontics prescribed narcotic analgesics most frequently while en-

dodontics and oral diagnosis prescribed penicillin products most frequently. A total of 349 patients were prescribed medications for home use during the four month period having an average age of 35.6 years. Medication for males and females was evenly distributed except in the department of periodontics which prescribed medication to a significantly greater number of females. The most frequent age group to be prescribed to was 20-34 years. Sixty-eight patients received two or more prescriptions during the period and 40 of these received two or more prescriptions simultaneously.

Introduction

The utilization of drugs by dental patients carries with it the risk of experiencing adverse effects due to drug toxicities and drug interactions. Some hospitals have reported as high as 20% of the patients admitted for

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reasons of adverse drug effects¹. A recent study identified 108 therapeutic drug interactions in 60 medical patients taking prescription medications². Although information concerning drug use by dental patients could be used to advantage in minimizing adverse drug effects, little information of this kind has been reported. Surveys concerning prescription writing by dentists which have been made available are deficient in most aspects of dental patient drug utilization^{3,4}. More useful data can be obtained by evaluating premedication administered before dental treatment, ancillary medication necessary during treatment, postmedication for home use and medications from other sources such as private physicians and self-medication.

A series of studies are in progress to evaluate these aspects of drug utilization by dental clinic patients at the University of Maryland School of Dentistry. This report is concerned with medication prescribed in the dental clinic for home use.

Methodology

Prescription blanks in pads of fifty were prepared so that each blank was in duplicate form and the duplicates serially numbered. The pads were provided to the dental clinic for the duration of the survey between February 9, 1972 to May 31, 1972. As prescriptions were written, the duplicates were collected for evaluation. Prescriptions written but voided for various reasons were also collected.

On each prescription was indicated the discipline responsible for writing the prescription, date, name, age and address of the patients, drug information, and signature of the instructor responsible for the pre-

scription. Prescriptions were evaluated according to drug analysis, prescriber analysis and patient analysis. A total of 665 numbered blanks were utilized during the survey, 438 of which were dispensed, 93 voided and 134 unaccounted for. All analyses were based on the total number of duplicate written prescriptions received.

Results

Prescription Analysis. Total medications prescribed represented ten therapeutic categories (Table 1). Narcotic analgesics were prescribed most frequently (40.6%) while penicillins, non-narcotic analgesics and non-penicillin antibiotics ranked 2nd, 3rd and 4th, respectively. These four categories represented 97% of all medications prescribed.

Evaluation according to products (Table 2) indicated penicillin V preparations to be most frequent (21%) with Empirin Compound w/codeine preparations and Darvon preparations a close second and third. As few as five products represented 75.4% of total medication prescribed. Evaluation according to trade names and strengths (Table 3) indicated Darvon Compound-65 to be most frequently prescribed (18.3%). Ten trade names represented 74.5% of all prescribed medications. Although ranking first, Darvon Compound-65 was the only non-narcotic analgesic in the group. Five narcotic analgesics were included and were represented by Empirin Compound w/codeine 30 mg, Phenaphen w/codeine 30 mg, APC w/codeine 30 mg, Percodan and Tylenol w/codeine 30 mg. Three different penicillin V products were included and Pen Vee K was more frequently prescribed than its counterparts V-cillin K or generic phenoxymethyl penicillin.

Prescriber Analysis. Prescriptions written in the dental clinic originated from five specialties (Table 4). In descending order, according to percentage of total prescriptions, the specialties ranked as follows: oral surgery, periodontics, oral diagnosis, endodontics and restorative dentistry. Pediatric dentistry was not included in the evaluation since they make it a practice to dispense medication to their patients. Oral surgery was responsible for over half of all prescriptions (63.0%) while restorative dentistry accounted for less than 2%. Table 4 also compares medication prescribed according to drug category and clinic specialty. The majority of prescriptions written by the departments of oral surgery and periodontics were for narcotic analgesics. In fact, for periodontics, over 50% of the medications were of this class. The departments of endodontics and oral diagnosis prescribed penicillin preparations most frequently. Interestingly, periodontics was the only department which prescribed more non-penicillin antibiotics than penicillins.

Table 5 compares the leading five products according to clinic specialty. Empirin Compound w/codeine preparations ranked first with oral surgery and periodontics while penicillin V products ranked first with endodontics and oral diagnosis. Darvon products ranked second with all specialties except restorative dentistry where it ranked first. Table 6 compares the leading trade names and strengths according to clinic specialty. Darvon Compound-65 was the most frequently prescribed trade name by oral surgery and restorative dentistry. Empirin Compound w/codeine 30 mg ranked first with periodontics. There occurred an even distribution between V cillin K 250 mg and Pen Vee K 250

mg in oral diagnosis while the former ranked first in endodontics.

Patient Analysis. A total of 349 patients received prescriptions during the survey with an even distribution occurring between sexes. The average age was 35.6 years (35.1 years males, 36.0 years females) with an age range of 12-84 years. Of the total, 68 patients received two or more prescriptions during the survey and 40 of these received two or more simultaneously.

Table 7 indicates the percentage age distribution of patients according to clinic specialty and sex. The most frequent age group for both males and females receiving prescriptions in all specialties except one was 20-34 years. Periodontics dispensed more prescriptions to the 35-49 age group. Also, periodontics prescribed medications for a significantly greater number of females.

Discussion

The ten therapeutic categories of medications observed in this study were very similar to the leading ten therapeutic categories of new prescriptions written by practicing dentists as reported in a national survey³.

The top four categories (narcotic analgesics, penicillin antibiotics, non-narcotic analgesics and non-penicillin antibiotics) accounted for 97% of the prescriptions in this study compared to the same top four categories nationally which accounted for 88.1% of all prescriptions.

Differences were observed according to products. Darvon preparations ranked first nationally while penicillin V preparations ranked first in the dental clinic. Similarities were observed according to trade name and strength and Darvon Compound-65 and Empirin Compound

w/codeine 30 mg ranked first and second in both studies. Pen Vee K 250 mg however while ranking third in the dental clinics ranked eighth nationally. The department of Oral Surgery prescribed most of the medication in the dental clinics and also prescribed the same three items more often than any other—narcotic analgesics, non-narcotic analgesics and penicillins. These findings are similar to the prescribing habits of oral surgeons reported nationally.⁴ Penicillin V was most preferred over all other penicillin derivatives by all specialties. While, according to product, penicillin V preparations ranked first in percentage of total number of prescriptions written, it ranked only first with the endodontic and oral diagnosis specialties.

The average age of patients receiving medication (35.6 years) compared favorably with the average age of prospective clinic patients (31.25 years)⁵. It is interesting to speculate on the observation that the most frequent age group receiving medication was 20-34 years for all specialties except periodontics where an older age group were prescribed to more frequently. Periodontal disease, more often than not, is more frequent in older age groups of a patient population. This same age group would therefore be expected to receive medication associated with dental treatment more often than younger ages. Observation on the number of patients receiving two or more prescriptions simultaneously

is of interest since any information concerning multiple drug therapy can be used in the screening and preventing of drug interactions with the use of drugs in dentistry⁶. Although 40 patients received two or more prescriptions simultaneously, in no case were any of the combinations observed to have a potential for interactions in the patient.

Knowledge of drug usage by dental patients can be utilized to prevent and monitor adverse drug reactions. New prescriptions written by dentists in 1969 were twice as many compared to 1962³. Also, an average of 79 prescriptions were written by each dentist responding to a survey of drug usage in dentistry⁴. This represented a substantial increase from previous years. The frequency and amounts of medication prescribed are therefore likely to increase in future years. Since the chance of adverse drug reactions increases with increasing amounts of medication taken by the patient, it is necessary to constantly evaluate drug usage by these patients.

This study has presented initial data obtained from a series of studies currently in progress. Future reports will be concerned with other aspects of dental patient drug utilization.

Acknowledgement

The authors wish to express their sincere thanks to Miss June Bingen of the Department of Oral Surgery for her assistance in carrying out this survey.

TABLE 1

Therapeutic Categories of Prescriptions Written in the Dental Clinic in a Four Month Period

<i>Rank</i>		<i>No.</i>	<i>%</i>
1	Analgesics: Narcotic	178	40.6
2	Antibiotics: Penicillins	118	26.9
3	Analgesics: Non-narcotic	92	21.0
4	Antibiotics: Non-penicillin	37	8.5
5	Hormones: Corticoids	3	0.7
6	Tranquilizers	3	0.7
7	Enzymes: Proteolytic	3	0.7
8	Hypnotics	2	0.5
9	Topical Anesthetics	1	0.2
10	Iron: Non-vitamin	1	0.2
TOTAL		438	100.0

TABLE 2

Leading Products Written in the Dental Clinic in a Four Month Period

<i>Rank</i>		<i>No.</i>	<i>%</i>
1	Penicillin V preparations	92	21.0
2	Empirin Compound w/codeine preparations	91	20.8
3	Darvon preparations	90	20.6
4	Phenaphen w/codeine preparations	35	8.0
5	Erythromycin preparations	22	5.0
PERCENT SHARE OF TOTAL PRESCRIPTIONS			75.4

TABLE 3

Leading Trade Names and Strengths Written in the Dental Clinic in a Four Month Period

<i>Rank</i>	<i>Trade Name and Strength</i>	<i>No.</i>	<i>%</i>
1	Darvon Compound-65	80	18.3
2	Empirin Compound w/Codeine 30 mg	75	17.1
3	Pen Vee K 250 mg	42	9.6
4	Phenaphen w/Codeine 30 mg	35	8.0
5	V-Cillin K 250 mg	33	7.5
6	Phenoxymethyl Penicillin 250 mg	16	3.6
7	Erythromycin 250 mg	13	3.0
8	APC w/Codeine 30 mg	12	2.7
9	Percodan	11	2.5
10	Tylenol w/Codeine 30 mg	10	2.2
PERCENT SHARE OF TOTAL PRESCRIPTIONS			74.5

TABLE 4

Prescriptions Written in the Dental Clinic in a Four Month Period According to Drug Category and Clinic Speciality

<i>Drug Category</i>	<i>Endodontics</i>		<i>Oral Diagnosis</i>		<i>Oral Surgery</i>		<i>Periodontics</i>		<i>Restorative</i>	
	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>
Narcotic Analgesics	5	1.1	3	0.7	124	28.3	45	10.3	1	0.2
Antibiotics: Penicillins	10	2.3	27	6.2	74	16.9	6	1.4	2	0.5
Non-Narcotic Analgesics	5	1.1	14	3.2	56	12.8	15	3.4	2	0.5
Antibiotics: Non-Penicillin	5	1.1	2	0.5	14	3.2	14	3.2	1	0.2
Miscellaneous	0	0.0	1	0.2	8	1.8	3	0.7	1	0.2
TOTAL AND PERCENT SHARE	25	5.6	47	10.8	276	63.0	83	19.0	7	1.6

TABLE 5

Prescriptions Written in the Dental Clinic in a Four Month Period According to Leading Drug Products and Clinic Speciality

<i>Preparations</i>	<i>Endodontics</i>		<i>Oral Diagnosis</i>		<i>Oral Surgery</i>		<i>Periodontics</i>		<i>Restorative</i>	
	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>
Penicillin V	9	2.1	27	6.2	50	11.4	5	1.1	1	0.2
Empirin Compound w/ Codeine	1	0.2	0	0.0	56	12.8	34	7.8	0	0.0
Darvon	5	1.1	14	3.2	55	12.6	14	3.2	2	0.5
Phenaphen w/ Codeine	2	0.5	0	0.0	33	7.5	0	0.0	0	0.0
Erythromycin	5	1.1	2	0.5	9	2.1	5	1.1	1	0.2
TOTAL AND PERCENT SHARE	22	5.0	43	9.9	203	46.4	58	13.2	4	0.9

TABLE 6

Prescriptions Written in the Dental Clinic in a Four Month Period According to Leading Trade Names and Strengths and Clinic Speciality

<i>Products</i>	<i>Endodontics</i>		<i>Oral Diagnosis</i>		<i>Oral Surgery</i>		<i>Periodontics</i>		<i>Restorative</i>	
	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>
Darvon										
Compound-65	4	0.9	12	2.7	48	11.0	14	3.2	2	0.5
Empirin Com- pound w/ Codeine 30 mg	0	0.0	0	0.0	41	9.3	34	7.8	0	0.0
Pen Vee K 250 mg	4	0.9	13	2.9	23	5.3	2	0.5	1	0.2
Phenaphen w/ Codeine 30 mg	2	0.5	0	0.0	33	7.5	0	0.0	0	0.0
V-cillin K 250 mg	5	1.1	13	2.9	12	2.7	2	0.5	1	0.2
Phenoxymethyl Penicillin 250 mg	0	0.0	1	0.2	14	3.2	1	0.2	0	0.0
Erythromycin 250 mg	3	0.7	1	0.2	4	0.9	4	0.9	1	0.2
APC w/ Codeine 30 mg	1	0.2	3	0.7	5	1.1	2	0.5	1	0.2
Percodan	0	0.0	0	0.0	8	1.8	3	0.7	0	0.0
Tylenol w/ Codeine 30 mg	1	0.2	0	0.0	4	0.9	5	1.1	0	0.0
TOTAL AND PERCENT SHARE	20	4.5	43	9.6	192	43.7	67	15.4	6	1.3

TABLE 7

Percent Age Distribution of Dental Clinic Patients Receiving Prescriptions—
According to Clinic Speciality and Sex

<i>Age</i>	<i>Endodontics</i>		<i>Oral Diagnosis</i>		<i>Oral Surgery</i>		<i>Periodontics</i>		<i>Restorative</i>	
	<u>M</u>	<u>F</u>	<u>M</u>	<u>F</u>	<u>M</u>	<u>F</u>	<u>M</u>	<u>F</u>	<u>M</u>	<u>F</u>
19 or under	1.1	0.4	1.8	1.1	1.8	4.2	1.1	0.4	0.0	0.0
20-34	1.4	2.8	2.8	3.9	13.3	12.3	1.8	4.6	0.4	1.2
35-49	0.0	0.6	0.6	1.1	6.3	5.6	2.1	7.4	0.0	0.0
50-64	0.6	0.0	1.4	1.4	4.9	3.5	0.7	2.8	0.0	0.4
Over 65	<u>0.0</u>	<u>0.4</u>	<u>0.0</u>	<u>0.0</u>	<u>1.4</u>	<u>0.6</u>	<u>0.0</u>	<u>1.4</u>	<u>0.4</u>	<u>0.0</u>
PERCENT TOTAL SHARE	3.1	4.2	6.6	7.5	27.7	26.2	5.7	16.6	0.8	1.6

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The Detection of Developing Vessels in Tooth Primordia Using the Dithizone Reaction and the Fast Green Staining Method of Van Gieson

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Abstract Blood vessels have been observed utilizing the histochemical demonstration of zinc in red and white blood cells and by the fast green staining method of Van Gieson. These techniques should provide a useful means of studying sequential development of blood vessels in tooth primordia.

The isolation and purification of erythrocyte carbonic anhydrase by Keilin and Mann (1940) has shown zinc to be an integral constituent of this enzyme. The presence of zinc was verified histochemically by dithizone reaction (Mager, McNary and Lionetti, 1953; Braun-Falco and Rathjens, 1956) and by Zn^{65} incorporation into newly formed red and white blood cells (Spencer, Rosoff, Feldstein, Cohn and Gusmano, 1965). We observed that histochemical demonstration of erythrocytic zinc enhanced detection of developing vessels in sections of tooth primordia. Vessels were

also demonstrable by the fast green staining method of Van Gieson.

Specimens were obtained from 14 to 17 day old fetuses of a non-specific strain of Swiss albino mice. Fetuses were decapitated and the whole heads were fixed in phosphomolybdic acid according to Pearse (1961). Specimens were dehydrated in a graded series of alcohols, cleared in xylene, embedded in paraffin, and sectioned either in frontal or sagittal planes. Serial sections (6 microns) were taken from areas of the mandibular first molars, affixed to glass slides and deparaffinized in xylene for 18 hours. Upon complete drying the sections were flooded with the dithizone reaction mixture (Mager, McNary and Lionetti, 1953) for 5 to 10 minutes.

The reaction mixture contains a complex-forming buffer (Braun-Falco and Rathjens, 1956) which binds all metals capable to complexing with dithizone into non-reactive com-

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plexed compounds. However, in the presence of thiosulfate and cyanate, dithizone is bound exclusively with zinc.

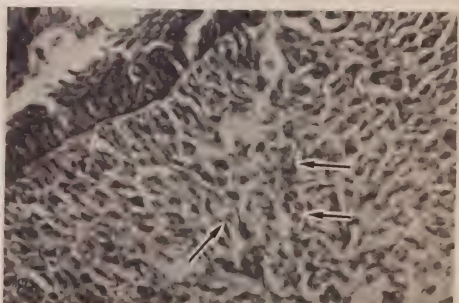
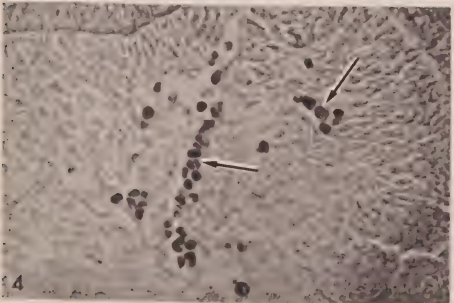
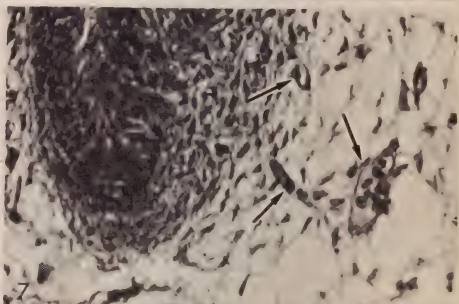
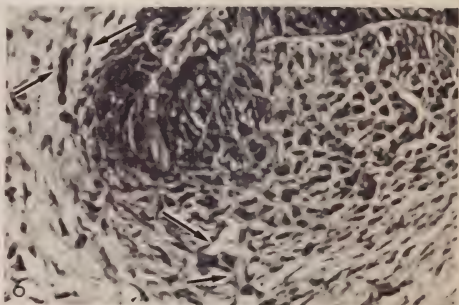
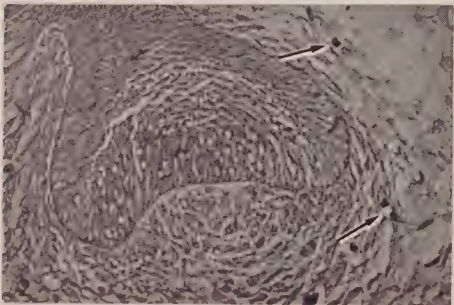
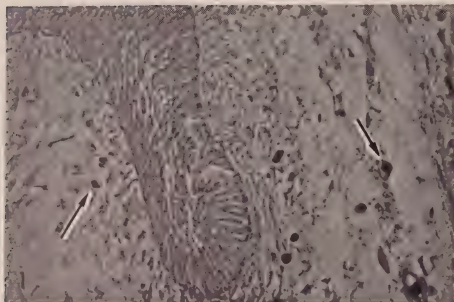
The excess dye was removed with chloroform, the slides were quickly rinsed in distilled water and mounted in Karo syrup.

Similar sections were stained by the fast green method of Van Gieson using 0.3% wool green S (C.I. No. 44090) instead of fast green (C.I. No. 82053) which results in bluer greens (Lillie, 1965).

Both erythrocytes and leucocytes stained red with the dithizone reaction (Figs. 1, 2, 3 and 4) and dark

green by the fast green method, the vessel walls being more easily identified by this latter method (Figs. 5, 6, 7 and 8).

Capillaries and small arterioles were noted proximal to the peripheral border of the developing dental papilla in the bud and cap stages of tooth development (Figs. 1, 2, 5, 6 and 7). The possible vascularization of the developing dental papilla in the late cap stage is suggested in Figs. 6 and 7. Vessel structure was more prominent, and capillaries and small arterioles were observed in the central area of the dental papilla in the bell stage (Figs 3, 4 and 8).



FIGURES

- Fig. 1. Bud stage of developing mandibular first molar. Arrows indicate blood cells exhibiting dithizone reaction. X 320
- Fig. 2. Cap stage of developing mandibular first molar. Arrows indicate blood cells. X 320
- Fig. 3. Early bell stage of developing mandibular first molar. Note developing vessels in central area of dental papilla. X 80
- Fig. 4. Enlarged area outlined in Figure 3. Note developing vessels and blood cells. X 120
- Fig. 5. Bud stage of developing mandibular first molar. Arrows indicate capillaries. Fast green Van Gieson. X 320
- Figs. 6 & 7 Cap stage of developing mandibular first molar. Arrows indicate vessels. Fast green Van Gieson. X 320
- Fig. 8. Area of dental papilla in early bell stage as seen in Figure 3. Arrows indicate blood cells and vessels. Fast green Van Gieson. X 120

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Format Recommendations For Contributors

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Two complete manuscripts with illustrations should be sent to the Editor, Journal, Baltimore College of Dental Surgery, University of Maryland School of Dentistry, Baltimore, Maryland, 21201. The articles which are submitted for publication are expected to follow the format suggested below. It is assumed that the papers are based on original data and that they have not been published or previously submitted for publication in other Journals.

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Each article should be sequentially arranged as follows:

- A. Summary
- B. Introduction
- C. Materials and Methods
- D. Results
- E. Discussion
- F. Acknowledgements
- G. References

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References cited in the text should include the author(s) last name and publication year as in "Doe and Brown (1966)". Multiple authorship (more than 2) is initially cited *in toto*, e.g. Doe, Brown and White (1966). Subsequent reference to the multiple authorship (more than 2) should be made as: Doe, *et al.*, (1966).

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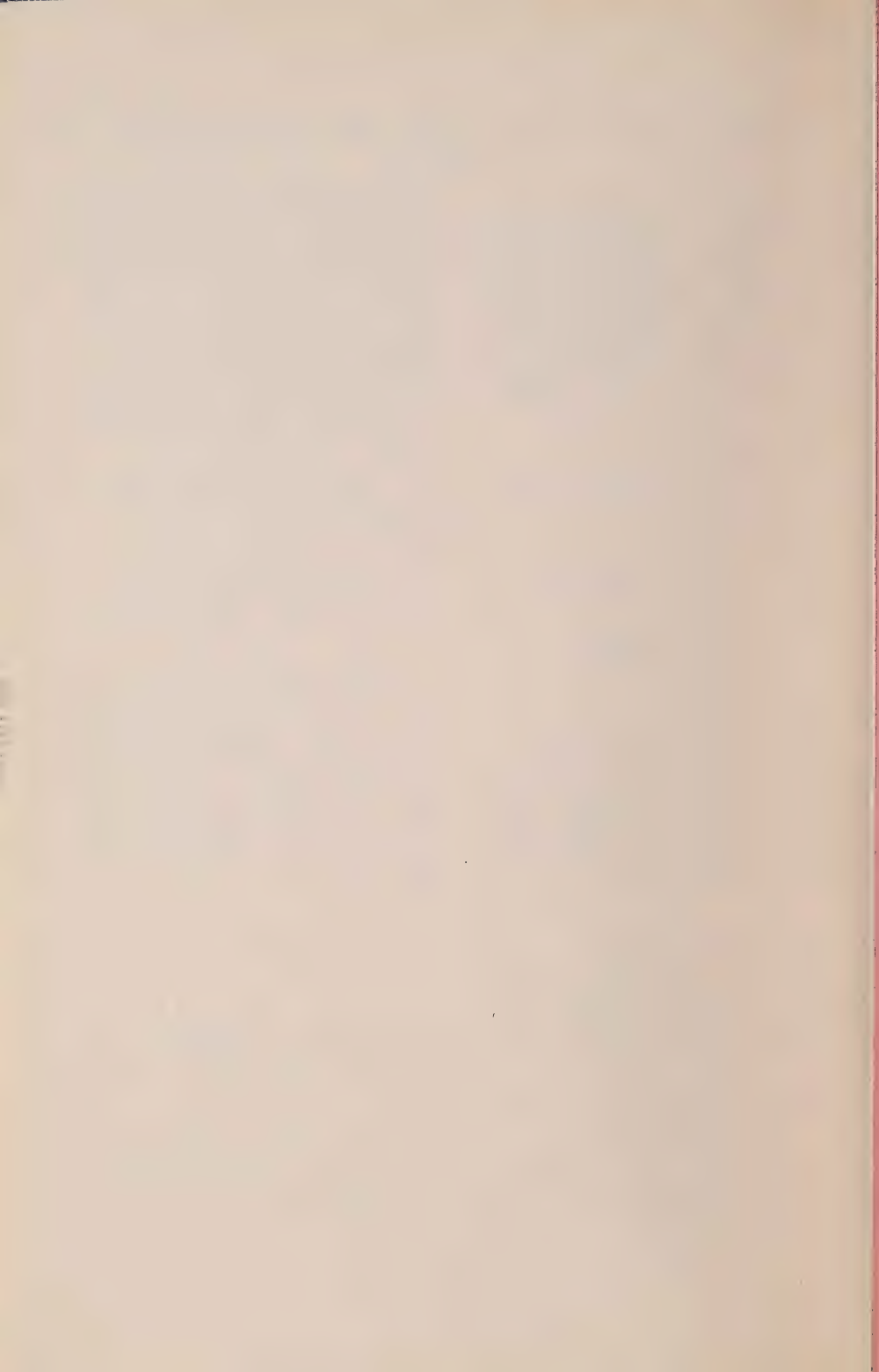
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A Learned Profession: "Its Responsibility"

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A Learned Profession: "Its Responsibility"

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I am deeply honored, indeed, flattered, to have been asked to give the Annual William B. and Elizabeth S. Powell Lecture at this historic and prestigious School of Dentistry. Although acceptance of the invitation was easy, selection of a subject proved more difficult. My first inclination was to talk about my specialty, oral surgery, and use the hour to review with you some of the advances in that discipline. However, on further reflection, it seemed more appropriate for one who is asked to speak at the world's first School of Dentistry, to discuss our learned profession and its responsibilities. Appropriate, because with the establishment of the Baltimore College of Dental Surgery in 1840, dentistry took an essential and fundamental step toward becoming a learned profession and with it assumed an entrusted responsibility.

Learned means having or demonstrating profound knowledge in scholarship while profession denotes a vocation or occupation requiring advanced training in one of the liberal arts or sciences which

involves mental rather than manual work. Dentistry, as a learned profession, demands that those who enter it have profound scholarship and knowledge of its art and science and assumes that those awarded the degree will be thinkers as well as doers.

After attaining an education beyond the usual level, the professional is expected to add to his basic knowledge and scholarship so he may continue to assume his responsibility of providing exemplary care to the public.

A review of the history of the healing arts indicates that the need for service created the health professions. Originally, it was believed disease was due to the supernatural or the result of offenses against the gods and relief from suffering was sought through consultation with the priests who supposedly possessed the ability to communicate with and appease the gods. Gradually through the centuries, the healing arts, including dentistry, became established on a more scientific basis. This was

*William B. and Elizabeth S. Powell Lecture. Presented by Charles A. McCallum, D.M.D., M.D., April 4, 1973, University of Maryland School of Dentistry, Baltimore, Maryland.

mainly due to the efforts of certain men who recognized the need for a scientific base. Individuals such as Pierre Fauchard, Ambroise Paré, John Hunter, and Leonardi de Vinci were the catalysts who helped to crystallize scientific thinking which eventually resulted in the establishment of our profession. Yet, at the time of the establishment of the American Colonies, those who practiced dentistry were preceptorship trained. Fortunately, Drs. Hayden and Harris, recognizing the need for a stronger emphasis on science, established the Baltimore College of Dental Surgery. Thus, through their efforts, those desiring to study dentistry had, for the first time, the opportunity to matriculate in a formal dental educational program. Evidence that the faculty at the Baltimore College of Dental Surgery held the awarding of the degree in high regard was acknowledged by the fact that a review of the school's records showed that a reputable individual who had practiced dentistry for 14 years was admitted to the examination for the D.D.S. degree but was rejected on the judgment of being altogether unworthy of this honor as he showed no acquaintance with the science of dentistry, being nothing more than a mere technician.

In 1867, Harvard established the first dental school to be affiliated with a university. The founders of the Baltimore College of Dental Surgery and the Harvard Dental School were convinced that the advancement of the profession of dentistry was dependent not only upon the mastery of the art of the profession but also upon a firm foundation in the sciences. Subsequently, our profession has been

richly rewarded by the integration of our academic programs with the university.

Although we can take pride in past achievements, we can ill afford to ignore the critical challenges facing our profession. As a learned profession, we must be prepared to resolve by appropriate planning and decisive action those issues confronting us if we are to discharge the trust given to us by the public. If a profession is to serve the people effectively, it must be appraised of changes occurring in society. Dr. Arthur S. Adams, former president of the American Council on Education, stated this rather explicitly in his remarks in the Foreword of the *Survey of Dentistry* when he astutely observed that, "The relation of a profession to the society it serves is an ever-changing one, for, as the society develops, it is inevitable that the profession must take account of that development if it is to continue to be effective. This fact has been recognized in all professions, with the result that comprehensive appraisals, or surveys, have been made from time to time to determine whether or not a given profession is fully meeting its current and prospective responsibilities."

The *Survey of Dentistry*, published in 1961 called to the profession's attention the problems which concerned society as related to dental health care and suggested changes that the dental profession should initiate if it was to meet the concerns and needs of society. The *Survey of Dentistry* recommended among other things the development of a flexible curriculum, more effective utilization of

auxiliaries, more involvement of dentistry in our hospitals, courses in practice administration, and an emphasis on developing within our profession and students more social concern with an understanding of their responsibility to the community. To say that the *Survey of Dentistry* was well received by the profession would be overstating the case. Only after considerable study, debate, and careful scrutiny by dental practitioners and educators were some of the recommendations accomplished. Even today, certain of the suggestions are still unacceptable to some; however, the *Survey* did invoke thought and much of what was suggested twelve years ago has now been accomplished.

During the fifties and sixties, significant social and economic changes occurred within the United States; changes which were to have a decided effect upon the health professions, their practice and educational institutions. Many in the academic and professional arena failed to perceive these changes; and when they crested in the late sixties, most were unprepared to formulate solutions. Even today many in the professions still are unaware or prefer not to recognize the challenges facing them, challenges which I call demands by the public on the health professions, including dentistry, for health care.

What events precipitated this period of public demand or social pressure on our health educational programs? After World War II there was an unprecedented population explosion in the United States. The post-war "baby boom" besides bringing considerable hap-

piness and, at times, surprises, created multiple problems, among which were the needs for additional schools, housing, teachers, recreational facilities, etc. To fully comprehend this population increase, one must appreciate that between 1950 and 1969, the population in the United States increased by 50.6 million or nearly one-third of the 1950 base. Coupled with the growth in population, the United States experienced a migratory phenomena heretofore unknown. Attendant with the rapid urbanization were the problems of transportation, housing, sustenance, education, but above all the problem of health, including environmental health, that required resolution. Concomitant with the population explosion and migratory trends, there was a surge of economic growth and industrialization resulting in rising prices and inflation.

People began to expect the best in homes, food, entertainment, and health. They wished to follow the full vigors of life in our rapidly expanding economy, and this demanded a healthy body and mind. The miracles in the health sciences which were acquired during the renaissance in the health professions (1910-1960) through research, technology, specialization, and the emergence of many new health workers were well known to our citizens. Kidney transplantation, cardiac surgery, renal dialysis, treatment of mental diseases, rehabilitative dentistry, and preventive measures were heralded by the people as a means of curing all and led them to the assumption that most anything and everything was possible. While believing this on one hand, they did little to as-

sure themselves of a healthy life. Individuals overindulged in the finer things of life, deprived themselves of sleep, maimed themselves in accidents, availed themselves of drugs and expected the health professions to cure and rehabilitate them. The cry became health care is a right of every citizen. Not only was it felt that health care was a right of all but that all should be entitled to the most sophisticated type of health services. Legislators, both at a local and national level, responded to the request of their constituents; and in the sixties, the government enacted and funded legislation which built new hospitals, provided moderate expansion of health school facilities, and underwrote extensive research programs. The availability of hospital beds made possible by the Hill-Burton Act and the emergence of private health insurance provided the facilities on the one hand and the money for health care on the other. By the mid-sixties, 70 percent of the population had some form of health insurance. In the late sixties, with the enactment of Title XVIII and Title XIX, commonly referred to as Medicare and Medicaid, practically every citizen had the financial barriers to many types of health care removed.

The citizens had been turned on by the miracles of health care, and they were ready whenever it was necessary "for some of the action" and the exemplary treatment of which they had been informed. Unfortunately, we in the health professions could not deliver that which was requested. We had been busily engaged in assuring quality and finding new means of treatment and prevention of disease, which had only been accomplished

by intense investigation and a commitment of the professions to a prolonged educational process and specialization. We had the quality but not the quantity to meet the demands of the public. Thus, the crisis in health manpower, including its attendant maldistribution, which is without a doubt the greatest challenge facing our profession.

The public now expects convenient, sophisticated, economically reasonable, and quality control or accountability from the health professions. To those of us who feel that quality control is indigenous to the 20th Century, I would remind you that in Babylonian times if a physician caused the loss of life or an eye to a patient, he had his hands cut off, if the patient was a gentleman, or had to render value for value if the patient was a slave. Personally, I prefer the current concept of peer review.

What are the solutions to our current dilemma? What road should we follow? I wish I had the answers. Had I, then the many national commissions, seminars, conferences, retreats, symposia, and endless reports which attempt to address themselves to the resolution of the problems would cease, which in itself would be a blessing. However, I shall attempt to address myself to the issues at hand.

Possible solutions to meet the ever-increasing demand for dental health care include better use of preventive measures, the development of new knowledge to control disease, the education of more dentists, increasing the productivity of the practitioner, and solving our problem of maldistribution of our health practitioners.

Undoubtedly, the best way to resolve the problem of oral disease is to prevent it. We currently have methods, which, if utilized, would practically eliminate caries from the population. These include fluoridation of water, good nutritional habits, application of topical fluoride, patient education in oral hygiene, motivation of patient, etc. Unfortunately, we in the profession of dentistry have been unsuccessful in assuming our responsibilities as doctors. Doctor means teacher as well as healer. We have demonstrated that we are effective at healing diseases but to date we have been ineffective in our roles as teachers of health. As a result, patients, because of our inability to motivate them, continue to suffer from caries and periodontal disease. In reality we are doctors of diseases, not doctors of health.

If, in fact, health is one of society's high priorities, we, as members of the health professions, should demand that appropriate and effective health education be a mandatory part of the curriculum at all educational levels, from grade school through college. It is my conviction that those who are educated, certified and employed as teachers should have completed an intensive course in health education, including dental health, and be well versed in the ills that result when sound health practices are disregarded.

Doctors, by themselves, cannot decree or will health; but hopefully, by enlisting the help of all in education, we may motivate people to preserve health, for it is undoubtedly one of our most precious national resources. It has been stated that if you cure cancer, you

would add one and one half years to the life expectancy of individuals; but, if through education, you could eliminate obesity, you would add four to six years of life expectancy. There is no more pressing problem in the U.S. today than that of exposing our youth, who are our future, to a health educational program which will inform them of the ill effects of drugs, smoking, alcohol, obesity, malnutrition, etc., on the well being of themselves, their society, and country.

Dentists, both individually and collectively, must be more vigorous in their attempts to influence legislators to enact laws making fluoridation of communal water supplies mandatory. It has been most refreshing to note the success of many of our colleagues in influencing their respective state legislatures to pass laws making fluoridation of community water mandatory. The last time I checked, six states had enacted such legislation and over 95 million people in the U.S. had fluoridated water. Considering that fluoridation of water supplies is one of the best known public health measures, it is difficult to understand why we have been unsuccessful in bringing this important health benefit to all Americans. I would suspect that, if we in the profession continue to vigorously support this measure, we will be successful. State legislatures are extremely sensitive to the rising costs of health care and providing them with facts about the cost of corrective therapy may provide the incentive to pass state fluoridation laws to assist us in preventing caries.

The facts which we can cite are:

dental caries affect 98 percent of the population and is the most prevalent affliction of children; over \$4 billion is spent each year for the treatment of caries; if all carious lesions were restored, it would cost \$10 billion a year; and the cost of dental care in fluoridated areas is fifty to sixty dollars less per child.

Another means of controlling dental disease is to discover new information which will assist us in eradicating and preventing its occurrence. Unfortunately, until relatively recently the opportunities for individuals to formally prepare themselves for a career of scientific investigation in dentistry were limited. It is true that some dedicated and astute clinicians have added considerably to our knowledge and a few institutions, notably Rochester and Harvard, provided at an early time the environment for a limited number of investigators to nurture their talents as scientists. But, it was only 25 years ago that dentistry was given its first significant scientific impetus by the founding of the National Institute of Dental Research. This Institute provided not only intramural investigative opportunities for those interested in dental research but also established the extramural support for dental research and for the training of deserving young investigators who are or will add much to our knowledge about the prevention and cure of dental diseases.

Research is classified by many as that which is relevant and that which is irrelevant or stated differently, some differentiate research into that producing an immediate versus a delayed result.

There are many in our profession who decry basic research and feel that the most important research to support is that which will reap immediate benefits. Similarly, there are those in influential positions in government who also support the theory that we should only provide monies for research which will have an immediate and identifiable result. Those in the scientific and academic community must support the concept of basic research as we all know that the basic investigations of today will provide the key to the solutions of tomorrow. The National Institute of Dental Research (NIDR) has found it appropriate to support fundamental research as well as research in the specific areas of caries, periodontal disease, etc. Investigations supported by the NIDR in crystallography, mineralization, microbial physiology, immunology, neurobiology, genetics, etc., will provide us with the information so necessary to solve the problem of oral diseases.

The monies provided by the NIDR for the support of scientific investigation has permitted research to become a way of life at most schools of dentistry. Prior to the establishment of the NIDR, American dental schools had little if any research base, and as such, were not fulfilling their mission as a true university discipline. With the addition of research into academic dentistry, an appropriate balance so essential to excellence was achieved. We in the universities owe much to the NIDR and the support from the government, for the medium of research in schools of dentistry not only permits us to meet our responsibility for the extension of knowledge but

also allows us to teach students as it is or will be rather than as it was.

Still another possible means of resolving the dental manpower shortage is to provide the facilities to matriculate, educate, and graduate more dentists. Although this solution is appealing, it is unrealistic to assume that even this affluent country is willing or able to allocate sufficient funds to provide the environment to educate the number of dentists required to meet the dental health needs of our citizens. Currently, the capital outlay necessary to provide the facilities to matriculate one dental student is between \$250,000 and \$300,000. Thus, to construct a school that could admit one hundred dental students would require an expenditure of somewhere between \$25 and \$30 million.

It is significant to note that between 1960 and 1970 the ratio of professionally active dentists (excluding those serving in the federal services) to the civilian population has not improved. In 1960 the ratio of dentist to population was 1:2,159, and in 1970, this ratio was 1:2,241, which reflects no improvement in the dentist-to-population ratio. During this same period of time, a substantial amount of federal and non-federal funds was invested for the rehabilitation and expansion of existing dental schools and the construction of new ones. Since the passage of the Health Professions Educational Assistance Act in 1963 until the present, there have been 1200 new places created for entering students in schools of dentistry. The creation of these 1200 new places was accomplished by the expenditure of over \$350 million of which

\$175 million was provided by federal funds. As previously mentioned, in spite of these increased facilities, the dentist-to-population ratio has not improved.

In my estimation, funds for additional new facilities are highly improbable. I base my reasoning on the evidenced reticence on the part of the federal, state, and private sectors to make available additional funds for capital outlay. Currently, there are no monies available for federal matching funds for schools of dentistry, medicine, or any of the health schools; and the long-range outlook is, at best, dismal. I would anticipate that the funding of monies for the construction of new schools or the expansion of existing schools will have to be borne by either the private or state sectors. Although I anticipate there will be some increase in enrollment in existing schools of dentistry, I doubt most seriously if we will see the establishment of more than two new schools of dentistry in the seventies. More likely, we may find several schools of dentistry closing because of severe fiscal constraints.

Another approach to resolving the dental manpower problem is the more effective and efficient use of certain dental auxiliaries; namely, the hygienist and assistant. Schools of dentistry have had a long and continuing interest in the effective utilization of auxiliary personnel. The development and refinement of four-handed dentistry has shown that it is possible to increase the productivity of a practitioner by 35 per cent. Additionally, some schools of dentistry have undertaken the task of determining which duties could be delegated to specially-trained dent-

al auxiliaries. A study was initiated at the University of Alabama in 1963 to determine the potential of specially trained dental auxiliaries to perform selected operative procedures traditionally reserved for the dentist. The functions which they *could not* perform were those which, in the judgment of the faculty, required the education, training, and expertise of a dentist. The functions *excluded* were the establishment of a diagnosis and the development of a treatment plan, the cutting of soft and hard tissues, the taking of impressions for the fabrication of appliances that would rest upon hard or soft tissue, the movement of teeth, and the prescription and administration of drugs.

The functions which the auxiliaries were to be trained to perform were reversible and could be corrected or redone without excessive discomfort or duress to the patient. These functions were:

1. taking impressions for study casts,
2. placing and removing rubber dams,
3. placing and removing temporary restorations,
4. placing and removing matrix bands,
5. condensing and carving amalgam restorations in previously prepared teeth,
6. placing of silicate and acrylic restorations in previously prepared teeth,
7. applying the final finish and polish to silicate and amalgam restorations.

The study was carefully designed, and defensible methods for evaluation were developed.

The results of these evaluations indicated that these auxiliaries with nine months of training could perform the previously mentioned procedures at least as well as senior dental students. A later comparison was made with highly respected dental practitioners; and again, the results indicated the auxiliaries performed as well as the experienced dental practitioners in those procedures selected for study.

I can state without equivocation that no other aspect of dental administration has provided more problems or held more challenges for me than that of initiating and carrying out an experimental program in the training and evaluation of the expanded duty dental auxiliary.

The mention of the term expanded duty dental auxiliary makes some dentists' blood exceed 212° F., and such an elevation is usually not secondary to any of the physical or intellectual attributes associated with individuals of the opposite gender.

Many in the profession viewed this experimental program with considerable alarm as they felt it was a threat to the practice of dentistry. However, we conducted these studies on the basis that it is the responsibility of the university to search for the truth and provide information that could be subsequently weighed, adopted, or rejected as deemed appropriate by our profession. I defend most vigorously the right of the university to search for the truth, just as I recognize and defend the right of our profession to provide the guidelines for the practice of dentistry in our states through their state practice acts.

It is refreshing to note that the profession in some states found it appropriate to change their state practice acts to permit auxiliaries to assume more responsibilities so that they, the profession, can render more care to their patients. The use of such auxiliaries could be most helpful to the profession in alleviating dental health manpower shortages as they arise.

Additional studies are needed on quality control, retention of these auxiliaries, and the effect that they might have on the cost of dental care. While some are concerned with whether or not the practitioner may gross or net more income from the use of such an auxiliary, the effect that this auxiliary might have on the cost of the dental care to the patient could be extremely important to the individual dentist, our profession and society. In my estimation, the previously mentioned studies can only be carried out or brought to fruition if there is mutual trust and understanding between those in the university and private practice. It is essential that we have this information if we as a profession are to make an appropriate decision about the future role of auxiliaries with expanded functions. However, I would hope that as the future roles of auxiliaries are investigated that those designing such studies would be realistic in the selection of which duties might appropriately be delegated to non-professionals.

Although I have dwelt considerably on the possible role that the dental auxiliary with expanded duties might assume in alleviating present and future dental manpower shortages, I would be remiss

if I did not indicate my bias by stating that one of the most important contributions auxiliaries with expanded functions can make is upon our educational programs. In 1957, Dr. Paul Hammons, at the University of Alabama School of Dentistry, initiated a carefully designed, clinical program which proved that the utilization of a conventionally trained dental assistant serving as a full-time chair-side assistant for junior and senior dental students had a complementary effect on the qualitative and quantitative performance of these students.

The first phase of the study was designed to determine the effect of a well trained conventional dental assistant on the clinical performance of junior students with deficiencies in operative dentistry. Sixteen students were selected to participate in the study. From this group, the eight students having the poorest performance in operative dentistry were assigned, on a rotating basis, two trained conventional dental assistants to operate with them during the second semester. The other eight students were to act as controls and were therefore not assigned dental assistants. The study group to whom the assistants were assigned had each received a failing grade in operative dentistry during the first semester. Each member of the control group had earned a minimal passing grade of "C" for the first semester. During the second semester, the study group, working with assistants, earned seven "C" grades and one failing grade. The control group, working without assistants, earned five "C" grades and three failing grades. It should be observed that while seven mem-

bers of the study group progressed from failing to passing, three members of the control group dropped from passing to failing. Additionally, the quality of work performed by the study group exceeded that of the control group.

The second portion of the study was designed to determine the effect of assigning dental assistants with traditional responsibilities to superior students. The students in the test group had three clinical semesters while their counterparts, who also had superior grades, had four semesters. The final evaluation revealed that the three semester study group completed as many restorative operations as their counterparts did in four full semesters. The quality of work performed by the test group was slightly superior to the control group of students who worked for four semesters without assistants. This indicated that with superior students the time necessary to complete a meaningful clinical experience could be reduced by 25 per cent if the operators were assigned well-trained assistants.

With the increasing interest evidenced by governmental agencies and dental educators to reduce the time required to educate competent dentists, it would seem imperative to integrate and investigate the impact that the expanded duty dental auxiliary might have in the undergraduate dental curriculum. This may well be the best means of shortening the length of the dental curriculum without compromising the quality of the educational experience. I am, therefore, persuaded that through the use of expanded duty dental auxiliaries, a dental student could dem-

onstrate a level of acceptable achievement in clinical dentistry in a shorter period of time. Additionally, I would propose that the student utilizing such an auxiliary should also be evaluated on his appraisal of the auxiliary's performance in order to prepare him to properly manage and efficiently utilize personnel in his future practice of dentistry. One of the frequent critiques that we hear of our dental education programs is that the student is not given an appropriate experience in practice management. The assignment of a student into an intramural simulated private practice environment, complete with auxiliaries, patients, etc., could do much to improve his insight into that important aspect of dentistry, practice management.

One of the most disturbing problems currently facing our profession is the problem of maldistribution of our manpower resources. Certain suburban areas show no evidence to support the concept of dental health manpower shortages, while in some of the inner city and rural areas such a shortage is obvious. We, as a profession, must solve this problem before others, less qualified, force a solution upon us which may be distasteful.

With temerity, I would like to propose a possible solution to the problem. It is suggested that states provide realistic loans to students attending our professional schools. These loans would provide funds for tuition, instruments, books, and living expenses. Such a program has already been adopted by the armed services in their attempt to identify, recruit, and maintain a stable cadre of health profes-

sionals for their respective service programs. States providing such loans to students could waive repayment of the loan if the recipient would subsequently serve a period of tenure in a manpower deficient area. This area could be determined by an appropriate committee from the profession in the state and the State Department of Health. A positive approach such as this could help solve our maldistribution problem and at the same time, provide funds for deserving students to attend professional schools whose attendance might otherwise be precluded.

During the remaining time that I have been allotted, I would like to reflect on the challenges and the opportunities in dental education, and more specifically, in the curriculum.

The dental manpower shortage has placed considerable pressure on schools of dentistry in the United States. The Comprehensive Health Manpower Training Act of 1971 (Public Law 92-157) made possible the awarding of a capitation grant to all schools of dentistry. Under this legislation each school was entitled to receive \$2500 for each enrolled student, providing the school increased its enrollment by a specified number, which for most schools was a 10 per cent increase in the entering class. Additionally, schools could receive a financial bonus of \$1,000 for all enrolled students by taking more than the mandatory increase in students and would receive still another bonus of \$2,000 for each student that graduated in three years or less. By passing this legislation, Congress made its intention clear; either increase the size of

your entering class or you will be ineligible for federal funds. All but two schools of dentistry applied for and received these capitation funds. Although there was a waiver clause in the act which permitted schools with inadequate facilities or other justified reasons to be exempted from the mandatory enrollment increase, of the eleven dental schools requesting a waiver only one request was granted.

The projected health manpower shortage coupled with the enticement by the Federal Government in the form of additional monies to shorten the dental curriculum or take bonus classes dictates that educational institutions must exercise care in order to preserve quality. To hasten the educational process and graduate ill-prepared, immature individuals with inadequate exposure in the science and art of dentistry will return the profession to the position it occupied at the beginning of this century; where the practitioner knew little of science, the art had been compromised, and he was, in fact, technique oriented. I trust that those in responsible positions within educational programs and the profession will not permit this to happen. However, I feel the profession should be aware that severe fiscal constraints in some schools could lead to a compromising of the quality of the educational experience if a three-year curriculum is adopted.

The dilemma caused by the projected dental manpower shortage, federal pressures, coupled with the maturity, sincerity, and aggressiveness of those entering dental education has provided us with

a unique opportunity to make a significant study of dental education. The enticement and opportunity to develop three-year curricula in schools of dentistry have encouraged most dental schools to carefully scrutinize their dental curriculum. This has resulted in many schools eliminating the antiquated and culling the unnecessary. It is most refreshing to note a challenging of the ossification of the curriculum and a hardening of the categories which have characterized the educational programs in many schools of dentistry. Fortunately, dental education is now becoming of age and is assuming its responsibilities as a true university discipline.

We are seeing changes in dental education which not only permit, but also encourage the exceptional student to either graduate earlier or have the opportunity to enter research, graduate or specialty studies sooner. Similarly, programs to identify and recruit the disadvantaged student into our profession, which has been long overdue, are becoming a reality.

For the most part, dental education has been wedded to a lock-step approach to teaching and has resisted the concept of electives, flexibility in curriculum, early specialization, or early graduation. We have been conservative, conventional, and unimaginative. There is a need for us to devote more time to electives, preventive measures, and individualize the educational experience to meet the needs of certain students who are preparing themselves to assume a role that might provide the profession and community with a unique skill, talent, knowledge or re-

souce that we need. Examples would be those preparing for a research or academic career, or those who may be interested in dental anesthesia who wish to have qualifications in medicine and dentistry and also the neurosciences. Should we not develop a program for these individuals who by nature of their background could make significant contributions to our profession and to those whom we serve? Should we not be flexible enough to excuse certain individuals, once they have demonstrated clinical ability, from performing certain repetitive procedures which, as I suggested previously, might be performed by auxiliaries in the years ahead? If this is the case, considerable time would be made available in the curriculum to permit the professional student to pursue other scholarly endeavors.

As mentioned previously, many schools have adopted a three-year curriculum; at last count thirteen, and by the 1973-74 academic year over 25 schools have indicated their intention to adopt a three-year curriculum. This three-year curriculum may be of two types; compressed or flexible. The compressed curriculum embraces a year-round educational experience but courses are still taught on a lock-step basis. On the other hand, in the flexible curriculum, educational objectives are defined and the curriculum is developed in such a manner that the student may progress at a rate consistent with his learning potential. When he satisfies the established essentials of the educational program he is either graduated or allowed to pursue a postdoctoral educational program. In this type of curriculum, there is no prerequisite set

in terms of time, only in terms of demonstrable acquisition of knowledge.

As schools contemplate a curriculum which operates on a calendar rather than an academic year, one prerequisite necessary to maintain excellence is the addition of more faculty. Failure to recognize this will compromise any semblance of scholarly endeavors.

In summary, pressures on educational institutions have dictated that administration, faculty, and students, carefully scrutinize the educational programs. This has been good. Not all schools are capable of developing innovative, imaginative, and progressive programs. However, for those that can, let them assume the responsibility of considering change, not

for change's sake alone but for the significant contributions that they may bring to our profession and society.

Yes, I think our profession and our educational institutions find themselves with great challenges but I look at them as great opportunities. Let us not discourage experimentation with our curricula or the means of delivering health care; but as we experiment, let us evaluate before we decide what is best for our patients, our profession, and ourselves. This dictates that all in the profession must become involved, including the student, practitioner, and educator. As Emerson so succinctly stated, "The things taught in schools and colleges are not an education, but the means of education."

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The Effect Of Thymectomy On The Fatty Acid Concentration Of Plasma, Liver And Fat Pads

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ABSTRACT

The relationship of the thymus to the adrenal glands and gonads has already received much attention with respect to effect on body weight and certain tissue weights. The purpose of this investigation was to establish the existence of a direct thymus influence on the fatty acid concentrations in serum, liver and fat pad tissues. Results of gas — liquid chromatographic analysis of the tissues indicate that certain differences were obtained both among and within the thymectomized experimental groups and their respective control and sham operated groups. Thymectomy increased the concentrations of the saturated fatty acids and, in many instances, reduced the concentrations of polyunsaturated fatty acids. Sex differences were not always uniform. Since many of the effects observed in thymectomized animals sacrificed at six months of age were similar to the

two month group, the effects of thymectomy can be classified as results of long duration.

INTRODUCTION

Within recent years investigators have tried to attribute a metabolic role to the thymus other than its activity in immunogenesis. A hyperglycemic activity of the thymus was reported by Bomskov and Sladovic (1) in 1940 and they advanced the thought of a possible existence of a thymus hormone. A year later Bomskov (2) demonstrated two effects of a lipid soluble substance from thymus tissue. This "hormone" appeared in the steroid fraction and was found to be relatively stable. One of its actions was an inhibitory influence on the effects of hyperthyroidism on oxidative reactions. This extract also produced severe depletion of heart-muscle glycogen when administered in excess to experimental animals.

Comsa and Bezssonoff (3) purified and assayed thymus extracts and tested the effect of adrenalectomy on the hormone content of the thymus. They obtained an active fraction from the thymus and a less active fraction from lymph nodes and spleen. Thymectomy resulted in a major decrease in the activity of the lymph nodes and spleen and it could be asserted that the possible hormone found in these tissues came from the thymus. The most convincing evidence for the existence of a thymus hormone was presented by Levey et al. (4), Law et al. (5) and Osoba and Miller (6) when they showed that the devastating effects of early thymectomy upon the development of the lymphoid system could be reversed by a thymic graft enclosed in cell tight diffusion chambers.

Phospholipase B was found to be present in thymus tissue by Ottolenghi et al. (7). This enzyme attacked lysolecithin resulting in the liberation of one mole of fatty acid. Phospholipase A has been reported to foster the same reaction. In a study of fatty acid changes after lethal body irradiation, Chung (8) reported a decrease in $C_{16:0}$ (n-hexadecanoic) and $C_{18:1}$ (9-octadecenoic) and a slight increase in $C_{18:2}$ (9, 12-octadecenoic), $C_{20:0}$ (n-eicosanoic) and $C_{20:4}$ (5, 8, 11, 14-eicosatetraenoic) acids in the liver. Following the irradiation, animals received injections of bone marrow, thymus and a combination extract. All three extracts increased the proportions of $C_{19:1}$, $C_{18:2}$, $C_{20:4}$ and to a lesser extent $C_{22:6}$ (docosahexaenoic) and $C_{22:4}$ (docosatetraenoic) acid; $C_{18:0}$ (n-octadecanoic) was decreased in the liver. Faschet et al. (9) found a decrease in lip-

protein lipase activity in the serum and heart muscle of rats after thymectomy.

This report is concerned with the possible role of the thymus as a participant in the regulation of lipid metabolism.

MATERIALS

All experimental animals were obtained from a breeding colony of thirty female and ten male Wistar strain albino rats. All animals were kept in wire bottom cages over wood shavings with Purina Laboratory Chow and water available *ad libitum*.

Fifteen of the thirty litters were randomly selected for neonatal thymectomies, sham operations and to serve as control animals. All newborn thymectomized and sham operated animals were returned to their respective mothers and remained with her until the male and female offspring were separated at four weeks of age.

Ten animals of each group were sacrificed at two months of age and all remaining animals were sacrificed at six months of age. The rats of the other fifteen litters were allowed to attain the age of four weeks at which time they were separated into male and female colonies. Forty animals, twenty males and twenty females, were selected at random to undergo thymectomies or sham operations. The remaining animals served as controls. Twenty rats of each group were sacrificed at two months of age and the remaining animals were sacrificed at six months of age.

From another group of eighty animals which had attained the age of twelve months, ten animals of each sex were thymectomized and another twenty were sham operated.

The remaining rats were used as controls. These adults were sacrificed at thirteen months of age. For each female animal, sacrificed at six months or older, the estrus stage was determined according to the method of Gorbman and Bern (10) and the animals were sacrificed at diestrus.

Thymectomy procedure

The weanling and adult rats were anesthetized with ether. A mid-ventral incision was made through the skin from a point 0.5 cm. above the thorax to the level of the fourth rib. Subcutaneous connective tissue and loose fascia was cut and teased aside and the neck muscles were separated at the midline. Prior to the actual opening of the thoracic cavity, two sutures were inserted; one at the level of the first costal cartilages and a second in the musculature between the second and the third ribs. Once in place, the sutures were lifted to one side in order to open the chest by cutting the costal cartilages slightly to the left of the sternum. With a pair of blunt forceps the thymus gland was gently loosened from its surrounding connective tissue and subsequently removed. The opening was closed immediately with the pre-set sutures and three additional sutures closed the neck muscles. All incisions were closed with linen thread.

The thymectomy procedure for neonatal rats was modified after Sjodin et al. (11). In order to effect satisfactory closure of the surgical opening, the tissue adhesive methyl-2-cyanoacrylate monomer (Ethicon Inc., Sommerville, New Jersey) was employed. Sham operations were performed in the same manner except that the thymus was left in place.

Tissue preparation and fatty acid analyses

The animals were sacrificed by decapitation and the blood was collected in chilled heparinized beakers and placed into trays containing crushed ice. The blood was centrifuged for thirty minutes at 2800 rpm in a clinical centrifuge at room temperature. The plasma was withdrawn and transferred to plastic vials and frozen with liquid nitrogen. The liver, adrenal glands and fat pads were excised and weighed. Epididymal fat pads from male animals and the adipose tissue of the ovary, ovarian tubes and kidneys of the females were selected for analyses. All tissues were frozen with liquid nitrogen and stored in a freezing compartment until use.

Fatty acid extractions and methyl ester preparations were patterned after Bottcher et al. (12). Through pilot experiments one gm. of liver, 0.5 gms. of fat pad and one ml. of plasma were found to be adequate for individual analyses.

Fatty acid analyses were carried out on a Beckman GC-4 chromatograph fitted with a hydrogen flame detector. Ultra pure helium served as the carrier gas. Two six foot U-shaped stainless steel columns, $\frac{1}{8}$ inch in diameter and packed with Chromsorb W-DMC, 60-80 mesh, and coated with 15% diethylene glycol succinate were employed. These columns were purchased from Applied Science Lab., Inc., State University, Pennsylvania. The columns were operated at a temperature of 180°C and both detector and inlet were maintained at 220°C. The flow rate of the carrier gas was adjusted to eighty ml. per minute, and air to two hundred ml. per minute.

Fatty acid methyl esters were identified by comparing their relative retention time to those of known fatty acid methyl esters. Standards were obtained from the Hormel Foundation and run before and at the end of each run. The percentage of fatty acid methyl ester was estimated from peak areas by triangulation.

RESULTS

Plasma and tissue fatty acids were identified according to their retention times and were reported as percentages of the total fatty acid concentration per tissue. These values represent mean values per experimental group. The significance ($P = 0.05$) of the individual observations was calculated with respect to the observed mean and Student's "t" for the respective degrees of freedom was inserted in this mathematical relationship for $P = 0.05$.

$$1_1 = \bar{x} - t .05 \bar{s}_x$$

$$1_u = \bar{x} - t .05 \bar{s}_x$$

In general, no significant differences were obtained among sham operated and control animals. Sex differences within experimental groups and their corresponding control groups were negligible in most instances. Noticeable, even if not significant differences, will be acknowledged in the course of this presentation. Only the major fatty acids were reported.

An overall examination of the data presented indicated the thymectomy seems to increase the level of 16:0 (palmitic or n-hexadecanoic) fatty acid in plasma, liver and fat pad. Stearic acid $C_{18:0}$ or (n-octadecanoic) also increased significantly whereas $C_{18:1}$ (oleic or 9-octade-

cenoic) and $C_{18:2}$ (linoleic or 9, 12-octadecadienoic) had a tendency to decrease. The polyunsaturated fatty acids such as $C_{18:3}$ (linolenic or 9, 12, 15 octadecatrienoic) and $C_{20:4}$ (arachidonic or 5, 8, 11, 14-eicosatetraenoic) showed the greatest variations among sex and age.

Fatty acids which occurred in lesser concentrations such as $C_{14:0}$ (myristic or n-tetradecanoic) and $C_{16:1}$ (palmitoleic or 9-hexadecanoic) showed generally little variation.

Comparisons of serum values of neonatal thymectomized animals (tables 1 and 2), sacrificed at two months of age, established several gross differences. Significant increases in $C_{16:0}$ (palmitic acid) were found among both males and females. The increase was much more pronounced among males. These observations were paralleled by $C_{18:0}$ (stearic acid). Arachidonic acid $C_{20:4}$ showed a significant increase among female thymectomized animals and an equally significant decrease among males of the same experimental group. Linoleic $C_{18:2}$ decreased significantly in both males and females; the greater drop occurred among the males.

Plasma fatty acids of the corresponding control groups presented the following picture. Palmitic acid $C_{16:0}$ was appreciably lower, whereas $C_{16:1}$ (palmitoleic) appeared in calculable amounts. Stearic acid, $C_{18:0}$ greatly decreased whereas oleic showed no change among males but significant increases were observed in female control animals. Linoleic acid, $C_{18:2}$ was present in much greater concentrations in the controls; $C_{18:3}$ (linolenic) and $C_{20:4}$ (arachidonic) showed no significant changes.

Values obtained for liver fatty acids were generally much more consistent within experimental and control groups as well as among them. Significant differences were found between experimental and control groups for all fatty acids except $C_{18:3}$ (linolenic). The $C_{16:0}$ and $C_{18:0}$ liver fatty acids of thymectomized animals increased significantly above their controls whereas $C_{18:1}$ and $C_{18:2}$ decreased. Arachidonic acid $C_{20:4}$ remained relatively stable.

Fat pad fatty acid showed no significant sex differences within experimental groups and no changes were observed among experimentals and controls for $C_{16:0}$ and $C_{18:0}$. Appreciable differences were found however for $C_{16:1}$, $C_{18:1}$ and $C_{18:2}$.

Tables 3 and 4 summarize the data obtained for neonatal thymectomized animals and their respective control groups sacrificed at six months of age. The results obtained were similar to those of the two month groups. Arachidonic acid $C_{20:4}$ concentrations in the plasma of female rats were greater than those of their male litter-mates. Palmitoleic acid $C_{16:1}$ showed a significant decrease when compared to neonatal thymectomized animals sacrificed at two months of age.

The results of analyses of the serum, liver and fat pad fatty acids of thymectomized weanlings sacrificed at two months of age are listed in tables 5 and 6. Sex differences showed no significant increases in $C_{16:0}$ and $C_{18:1}$ while $C_{18:0}$ and $C_{18:2}$ decreased. Liver fatty acids exhibited significant differences for $C_{18:0}$, $C_{18:2}$ and $C_{20:4}$. Fat pad

fatty acid changes were extremely minimal for $C_{14:0}$ and $C_{18:0}$.

Fatty acid concentration changes of thymectomized weanlings sacrificed at six months of age are reported in table 7 and 8. Males of this experimental group exhibited drastic reductions in $C_{16:0}$ when compared to weanling thymectomized males sacrificed at 2 months. Stearic acid $C_{18:0}$ increased in both males and females but the changes observed in males was markedly greater. The unsaturated fatty acids of the stearic series showed marked reductions for $C_{18:1}$, increases for $C_{18:2}$ and $C_{18:3}$ present only in trace amounts. Arachidonic acid $C_{20:4}$ also showed significant increases. Myristic acid $C_{14:0}$ appeared in measurable amounts in both experimentals and controls. Also, the control animals of this experimental group did not differ significantly from their two months counterparts.

The liver analyses almost paralleled the fatty acid picture of thymectomized weanlings sacrificed at two months. No significant differences were observed for stearic acid $C_{18:0}$ between the thymectomized animals and their controls. Appreciable changes were noticeable however when the two and six months groups were compared. Similar observations can be made for the fat pad fatty acids.

The results for adult thymectomized animals are listed in tables 9 and 10. In general, no significant differences were found among thymectomized and control groups. There are, however, occasional exceptions which do not contribute greatly to the interpretation of the data for this group.

DISCUSSION

It is perhaps too early to prove conclusively that the observed effects of thymectomy are solely due to the absence of this gland. Important and noteworthy however is the fact that the responses obtained are not due to stress reactions encountered during post-operative periods because in many cases the same fatty acid levels were found in animals sacrificed at six months as those present at two months.

Since an overall decrease in unsaturated serum fatty acids was found, it would be of interest to compare these results with those found in experimentally induced atherosclerosis and aging animals with involuted thymus glands. Un-

fortunately, great variations exist for serum fatty acids.

Major differences attributable to sex indicated that an increase in the proportion of one fatty acid in the female would be matched by a corresponding decrease in the male. Arachidonic acid concentrations offer a striking example. These changes may be due to the influence of the thymus on the maturing gonads as well as the level of the adrenal steroids.

A study is in progress to reverse some of the effects of thymectomy by the addition of an adult or a weanling thymus extract. Administration of weanling thymus extract has thus far given favorable indications for reestablishing a normal status quo.

TABLE 1
FATTY ACID CONCENTRATIONS OF PLASMA, LIVER AND FAT PAD OF NEONATAL THYMECTOMIZED
FEMALE RATS SACRIFICED AT TWO MONTHS OF AGE

FATTY ACID	PLASMA			LIVER (% of total fatty acid concentration)			FAT PAD (% of total fatty acid concentration)		
	NT*	SO†	C‡	NT	SO	C	NT	SO	C
14:0	t†	t	t	t	t	t	t	1.66	1.57
16:0	24.83	17.91	17.34	33.11	26.87	26.36	28.28	27.92	28.36
16:1	t	1.12	1.47	t	1.08	1.73	4.19	1.44	1.62
18:0	17.94	8.33	6.94	30.02	11.85	13.26	1.58	1.29	1.08
18:1	16.45	22.81	23.68	10.14	18.52	18.42	37.38	29.01	29.13
18:2	18.05	30.47	32.05	15.94	23.28	23.75	27.98	38.14	37.46
18:3	---	t	1.59	---	t	t	t	t	t
20:4	22.70	11.61	12.46	10.18	10.95	13.42	---	---	---

*NT—Neonatal thymectomized

†SO—Sham operated

‡C—Control

t—trace amount

TABLE 2
FATTY ACID CONCENTRATIONS OF PLASMA, LIVER AND FAT PAD OF NEONATAL THYMECTOMIZED
MALE RATS SACRIFICED AT TWO MONTHS OF AGE

FATTY ACID	PLASMA			LIVER (% of total fatty acid concentration)			FAT PAD (% of total fatty acid concentration)		
	NT*	SO†	C‡	NT	SO	C	NT	SO	C
14:0	t†	t	t	t	t	t	t	1.01	1.16
16:0	32.59	18.29	18.52	32.85	24.17	26.22	27.43	28.76	29.07
16:1	t	1.44	1.47	t	1.82	2.14	4.27	1.27	1.40
18:0	34.85	5.66	6.81	30.55	13.72	13.65	1.14	1.67	1.61
18:1	21.46	21.93	22.49	10.21	17.93	18.59	37.22	30.18	29.72
18:2	4.19	30.43	30.26	16.25	21.63	22.38	27.56	38.81	39.93
18:3	—	1.26	1.46	—	t	t	t	t	t
20:4	t	10.44	11.73	10.09	10.07	13.72	—	—	—

*NT—Neonatal thymectomized

†SO—Sham operated

‡C—Control

t—trace amount

TABLE 3
FATTY ACID CONCENTRATIONS OF PLASMA, LIVER AND FAT PAD OF NEONATAL THYMECTOMIZED
FEMALE RATS SACRIFICED AT SIX MONTHS OF AGE

FATTY ACID	PLASMA			LIVER (% of total fatty acid concentration)			FAT PAD (% of total fatty acid concentration)		
	NT*	SO†	C‡	NT	SO	C	NT	SO	C
14:0	t*	1.49	t	t	t	t	1.63	1.55	1.92
16:0	24.95	18.47	17.46	32.90	25.26	24.92	25.61	29.34	29.17
16:1	5.18	1.61	1.83	t	t	1.14	4.78	2.71	2.68
18:0	16.44	7.25	7.33	29.86	21.74	25.18	2.37	3.11	2.80
18:1	16.05	23.45	22.68	10.25	13.13	13.29	35.68	39.58	40.19
18:2	18.32	29.86	29.38	15.11	20.77	20.22	30.73	21.92	21.70
18:3	—	1.65	1.42	—	t	t	t	—	—
20:4	20.18	10.06	9.08	10.15	15.27	16.84	—	—	—

*NT—Neonatal thymectomized

†SO—Sham operated

‡C—Control

*t—trace amount

TABLE 4
FATTY ACID CONCENTRATIONS OF PLASMA, LIVER AND FAT PAD OF NEONATAL THYMECTOMIZED
MALE RATS SACRIFICED AT SIX MONTHS OF AGE

FATTY ACID	PLASMA			LIVER (% of total fatty acid concentration)			FAT PAD (% of total fatty acid concentration)		
	NT*	SO†	C‡	NT	SO	C	NT	SO	C
14:0	t†	1.07	1.74	t	t	t	1.42	1.16	1.30
16:0	29.52	16.57	17.87	32.84	21.79	22.97	25.08	30.81	29.92
16:1	t	1.27	1.44	t	t	t	4.11	2.63	2.24
18:0	24.65	7.47	7.22	30.12	25.77	25.51	2.49	1.70	1.84
18:1	21.06	23.26	22.72	10.37	13.06	11.49	35.94	41.20	41.62
18:2	15.41	27.24	28.74	15.08	20.49	20.08	31.05	21.82	22.64
18:3	—	1.06	1.41	—	t	t	t	t	—
20:4	10.22	9.87	8.38	10.46	9.42	9.93	—	—	—

*NT—Weanling thymectomized

†SO—Sham operated

‡C—Control

†t—trace amount

TABLE 5
FATTY ACID CONCENTRATIONS OF PLASMA, LIVER AND FAT PAD OF WEANLING THYMECTOMIZED FEMALE RATS SACRIFICED AT TWO MONTHS OF AGE

FATTY ACID	PLASMA			LIVER (% of total fatty acid concentration)			FAT PAD (% of total fatty acid concentration)		
	WT*	SO†	C‡	WT	SO	C	WT	SO	C
14:0	t+	t	t	t	t	t	t	1.72	1.84
16:0	36.15	17.66	18.47	22.21	26.14	26.82	33.42	29.79	27.68
16:1	t	1.46	1.24	1.12	1.73	1.98	3.85	1.72	1.64
18:0	t	8.41	7.68	24.87	12.61	13.84	1.62	1.14	1.32
18:1	39.54	22.56	22.51	18.14	18.96	18.46	39.44	25.82	28.73
18:2	24.22	29.11	31.81	17.69	23.15	23.66	20.91	31.18	29.64
18:3	---	1.64	1.46	t	t	t	---	---	---
20:4	---	10.57	11.66	21.51	11.62	13.80	---	---	---

*WT—Weanling thymectomized

†SO—Sham operated

‡C—Control

+t—trace amount

TABLE 6
FATTY ACID CONCENTRATIONS OF PLASMA, LIVER AND FAT PAD OF WEANLING THYMECTOMIZED
MALE RATS SACRIFICED AT TWO MONTHS OF AGE

FATTY ACID	PLASMA			LIVER (% of total fatty acid concentration)			FAT PAD		
	WT*	SO†	C‡	WT	SO	C	WT	SO	C
14:0	t†	t	t	t	t	t	t	1.48	1.32
16:0	37.02	18.47	19.46	24.13	25.39	26.41	32.84	29.84	31.68
16:1	t	1.21	t	1.41	1.77	2.97	3.23	1.04	1.27
18:0	t	6.42	5.66	23.09	13.56	13.61	1.51	2.13	1.92
18:1	38.75	21.37	20.73	16.53	17.47	18.52	39.78	32.66	34.81
18:2	24.18	30.18	29.68	17.60	20.04	21.47	22.06	34.91	36.84
18:3	—	1.74	1.90	t	t	t	—	t	t
20:4	—	10.76	9.27	22.13	12.15	13.48	—	—	—

*WT—Weanling thymectomized

†SO—Sham operated

‡C—Control

t—trace amount

TABLE 7
FATTY ACID CONCENTRATIONS OF PLASMA, LIVER AND FAT PAD OF WEANLING THYMECTOMIZED
FEMALE RATS SACRIFICED AT SIX MONTHS OF AGE

FATTY ACID	PLASMA			LIVER (% of total fatty acid concentration)			FAT PAD (% of total fatty acid concentration)		
	WT*	SO†	C‡	WT	SO	C	WT	SO	C
14:0	1.05	1.40	1.24	t*	t	t	1.04	1.27	1.31
16:0	27.76	18.29	17.28	21.96	25.87	25.41	29.14	32.86	31.48
16:1	t	1.42	1.29	1.01	t	t	3.58	2.91	3.16
18:0	4.70	7.45	6.49	25.56	25.22	25.62	1.57	2.78	2.56
18:1	7.62	22.06	23.52	18.13	12.47	13.14	37.61	41.64	38.19
18:2	31.98	30.51	28.19	17.66	20.29	20.62	27.62	21.86	25.94
18:3	22.30	1.08	t	t	t	t	t	—	—
20:4	2.68	9.49	9.27	22.81	14.38	17.08	—	—	—

*WT—Weanling thymectomized

†SO—Sham operated

‡C—Control

*t—trace amount

TABLE 8
FATTY ACID CONCENTRATIONS OF PLASMA, LIVER AND FAT PAD OF WEANLING THYMECTOMIZED
MALE RATS SACRIFICED AT SIX MONTHS OF AGE

FATTY ACID	PLASMA			LIVER (% of total fatty acid concentration)			FAT PAD		
	WT*	SO†	C‡	WT	SO	C	WT	SO	C
14:0	t*	1.04	1.04	t	t	t	1.17	1.34	1.04
16:0	19.63	16.25	17.14	23.82	22.41	23.08	29.53	33.74	34.96
16:1	t	1.25	1.72	1.12	t	t	4.22	3.11	3.58
18:0	15.04	8.42	8.38	24.91	24.22	25.31	1.89	1.64	1.79
18:1	20.57	22.03	24.46	17.40	12.23	13.57	27.32	35.72	36.89
18:2	24.16	29.15	29.22	17.12	20.23	19.51	35.76	26.81	25.14
18:3	t	1.41	1.25	t	t	t	t	t	---
20:4	19.77	9.93	9.42	21.94	10.93	10.14	---	---	---

*WT—Weanling Thymectomized

†SO—Sham operated

‡C—Control

t—trace amount

TABLE 9
FATTY ACID CONCENTRATION OF PLASMA, LIVER AND FAT PAD OF ADULT THYMECTOMIZED
FEMALE RATS SACRIFICED AT 13 MONTHS OF AGE

FATTY ACID	PLASMA			LIVER (% of total fatty acid concentration)			FAT PAD		
	AT*	SO†	C‡	AT	SO	C	AT	SO	C
14:0	1.34	1.46	1.63	t*	t	t	2.21	1.58	1.63
16:0	18.02	18.22	19.14	24.86	23.62	25.84	26.38	29.71	28.74
16:1	1.06	1.18	1.66	t	t	t	4.62	2.05	2.92
18:0	8.11	7.98	4.81	30.92	25.87	25.09	2.57	3.15	2.63
18:1	27.02	22.28	23.33	9.90	12.26	13.36	44.73	39.66	40.11
18:2	29.52	30.40	29.47	16.04	20.65	20.57	21.91	22.43	22.09
18:3	3.17	1.95	1.06	t	t	t	t	—	—
20:4	16.58	10.82	9.43	17.95	16.02	17.46	—	—	—

*AT—Adult thymectomized

†SO—Sham operated

‡C—Control

t—trace amount

TABLE 10
FATTY ACID CONCENTRATION OF PLASMA, LIVER AND FAT PAD OF ADULT THYMECTOMIZED
MALE RATS SACRIFICED AT 13 MONTHS OF AGE

FATTY ACID	PLASMA			LIVER (% of total fatty acid concentration)			FAT PAD (% of total fatty acid concentration)		
	AT*	SO†	C‡	AT	SO	C	AT	SO	C
14:0	1.53	1.51	1.07	t†	t	t	1.10	1.15	1.21
16:0	17.89	15.88	16.19	22.13	22.60	23.15	23.94	31.46	30.68
16:1	1.11	1.43	1.18	t	t	t	4.46	2.13	2.47
18:0	8.42	6.87	7.46	30.44	25.98	25.66	1.11	1.55	1.81
18:1	26.54	22.19	21.35	10.17	12.62	13.11	41.27	39.73	41.93
18:2	30.25	29.46	24.81	16.43	20.14	19.73	28.34	23.87	22.64
18:3	2.88	1.33	t	t	t	t	t	t	t
20:4	15.76	10.46	9.77	19.26	10.11	10.82	—	—	—

*AT—Adult thymectomized

†SO—Sham operated

‡C—Control

t—trace amount

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The Odontoma: Study And Discussion

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SUMMARY

The following paper is a study of odontomas diagnosed at the University of Maryland School of Dentistry, and University Hospital, Baltimore, Maryland, during the last decade. Forty-one odontomas are reported in terms of anatomic distribution, age, sex and race. A discussion is offered in an attempt to relate histologic and embryologic phenomena with some of the observed statistical findings.

INTRODUCTION

The odontoma is a common odontogenic tumor. Despite the frequent occurrence of the odontoma, previous studies have failed to present consistent numerical data. The origin of this tumor is still not completely elucidated. While it has been classified with odontogenic neoplasms, it is generally accepted to be a hamartoma.^{1,2,4,5,7,8,9,14,15} The present study concerns odontomas diagnosed at University Hospital, Baltimore, Maryland, and the University of Maryland School of Dentistry from 1963 through July, 1972. No distinction has been made between complex or compound odontomas; as these designations are arbitrary and, therefore, not useful. It is hoped

this study will help clarify the subject of the odontoma.

REVIEW OF THE LITERATURE

The term odontoma originally referred to any tumor of odontogenic origin. Through a century of inconsistent usage, the odontoma has been redefined as a benign tumor composed of enamel, dentin, cementum and pulp tissue.^{7,9,22,23} No other consistent histologic findings have been reported. While odontogenic tumors are rare compared to all other tumors, Baden¹ estimates their incidence at about .003% of all surgical specimens received at large centers. The odontoma has a fairly high incidence among odontogenic tumors, at about 15% as found in Bhaskar's survey of 429 lesions.^{2a} In recent years, many investigators have classified the odontoma as a hamartoma instead of a neoplasm.^{1,2,4,5,7,8,9,14,15} A hamartoma is essentially a dysontogenic mass showing a faulty mixture of the normal components of the organ in which it resides.¹⁸

While odontomas are usually reported as compound or complex, many authors question this arbitrary line of distinction.^{4,9,10,19} The following data is presented to

serve as a reference for propositions discussed later in this paper. The complex odontoma, bearing little resemblance to normal teeth, represents 25% of all odontomas.¹ There is dissension regarding the predilection for females.^{1,4,8,9,23} Seventy per cent appear in the premolar or molar region^{8,19} with a predilection for the mandible.^{8,9} The compound odontoma, resembling normal teeth, represents 60% of all odontomas;¹ there is no sex predilection.^{1,10} The majority occur in the incisor-cuspid region with an increased tendency to occur in the maxilla.⁹ Both compound and complex odontomas are usually diagnosed in the second to third decades.^{4,8,9} Combinations of complex and compound odontomas have been observed.¹⁰

Both compound and complex odontomas have been produced experimentally in animals by mechanical, chemical and nutritional means.^{3,12,15,16,21} A definite correlation has been shown between Vitamin A deficiency and maldevelopment of hamster and rat teeth.^{3,21} In one study, 62% of the rats on a chronic Vitamin A deficient diet developed odontomas, and a few developed supernumary teeth as well.³ In another experiment, a complex and a compound odontoma were induced with N-methy-N-nitrosurea.¹² Two other studies showed that physical trauma could produce odontomas as well as anomalous teeth.^{15,16} One of these studies produced anomalous impacted teeth in 75% of the rats subjected to physical trauma.¹⁶ However, these were not considered odontomas despite their histologic features, because they were not in excess of the expected normal complement of teeth.

Other odontomas are associated with unerupted teeth.^{9,10,23} In a review of 292 cases it was found that in 75% of the cases there was an absence of the tooth corresponding to the tumor site in the dental arch.²³ In this same study it was determined that, contrary to popular opinion, only 18% of the odontomas were incidentally discovered on routine radiology. The remaining 82% presented with a combination of expansion, swelling and/or pain.

Multiple odontomas² have been reported as well as a giant odontoma.¹¹

METHODS AND MATERIALS

The University of Maryland School of Dentistry and the University Hospital biopsy records were studied and the following variables were recorded on a standardized data sheet prepared prior to data collection: anatomic distribution, age, sex, and race.

Sections from every biopsy were re-examined in co-operation with a member* of the University of Maryland School of Dentistry, Department of Oral Pathology. Reference to previous diagnoses was avoided to prevent a prejudiced review of the section.

Sex and Race:

There were 26 (74%) Caucasians, of which 19 (73%) were female, and seven (27%) male. Nine (26%) were found in Negroes, of which three (33%) were female and six (67%) male. There was a total of 24 (59%) females and 17 (41%) males.

*Dr. Bernard A. Levy

Age:

Out of 41 cases where the age was recorded, there was an age spread from eight years to 50 years. The median age was 15 years, the mode was 15 years, and the mean was 20.7 years. The second decade showed the largest number of odontomas, 47.5% while the second and third decades comprised 62.5% of the cases (Table I).

Anatomic Distribution:

The tumor occurred in both jaws with approximately equal frequency (Table II). It is interesting to note that the odontomas were

found more often in the anterior (83.4%) of the maxilla and in the posterior (64.4%) of the mandible.

Histologic Observation:

All of the odontomas exhibited various arrangements of enamel, dentin, cementum, and pulp tissues. (See Figures 1 & 2). Figure 3 shows an odontoma which presented with cementum, enameloid and droplets of calcification. Figure 4 illustrates what is described by some authors^{20,22} as a dilated odontoma. A significant number of odontomas contained epithelial ghost cells. This is a finding not previously described and will be studied in depth in a later paper.

TABLE I.

Age Distribution:

Decade of life.....	1st	2nd	3rd	4th	5th	6th
No. of Cases.....	6	19	6	4	5	1

TABLE II.

Anatomic Distribution:

	Anterior	Posterior	Total
Maxilla.....	15	3	21 (57%)
Mandible.....	5	9	16 (43%)

DISCUSSION AND CONCLUSIONS

The findings of this study are in agreement with some of the previously reported surveys of odontomas. 47.5% of the odontomas were discovered in the patients' second decade. 83.4% of maxillary odontomas occurred in the anterior region and 64.4% of mandibular odontomas were discovered in the posterior region. The incidence of odontomas in females was 59%,

while 41% were males.

It is perhaps to be expected that more so-called complex odontomas are found in the premolar-molar areas, as the dental lamina here regularly produces tooth buds with multiple foci of odontogenic activity which normally produce multi-cusped teeth. Similarly, the predominance of compound odontomas in the anterior region of the jaws would correspond to areas where fewer cusps normally develop.

Evidence to date implicates a wide variety of etiologic factors, of which three have been proven.^{3, 12, 15, 16, 21} In contrast to most other tumors, odontomas present with a myriad of internal histologic components.^{7, 9, 22, 23} Perhaps this is a result of early embryologic changes involving trauma to the dental primordium, Vitamin A deficiency, etc., as opposed to later changes as is often suggested.^{5, 10} It is entirely conceivable that more complex tumors would result if in histogenesis those cells destined to participate in cusp proliferation were disturbed or were genetically incomplete. This could permit multiple areas of proliferation. If those areas of odontogenic proliferation were allowed to continue through morphogenesis and histogenesis, they might result in a proportionate number of single cusped, small, toothlike structures. If contact occurred early in their development, a conglomerate of enamel, dentin pulp and cementum may result. Accordingly, if some environmental or genetic factor effects cell division prior to internal differentiation, the daughter cells would possess the identical multipotentiality of their progenitor cells. From this it is not difficult to deduce that an infinite number of embryologic defects may result from a multiplicity of stresses complicating the histogenesis of the growing tissue mass.

It has been shown that the odontogenic epithelium is the *sine qua non* for odontoblastic induction,⁶ as well as the determining influence in the morphogenesis of the tooth.¹⁷ Furthermore, the odontogenic epithelium is sensitive to environmental conditions, physical trauma, experimental chemicals,

and nutritional deficiencies, which have a pronounced effect on the enamel organ. Eversole⁵ has proposed a "maturation factor" necessary for normal continued differentiation of tissue. Perhaps this factor is in turn dependent on Vitamin A and other cofactors, or in the case of local inflammation this "maturation factor" may be leached out of a cell or cause a premature maturation response. Regardless of the mode of disruption to the odontogenic epithelium resulting in loss of control over morphogenesis, Huggins,¹³ et al. and Zussman & Iochim²⁴ have demonstrated that differentiated odontoblasts can proliferate and produce dentin in the absence of this odontogenic epithelial component. Indeed, most classifications describe odontomas as lacking proliferating ameloblastic epithelium.^{4, 8}

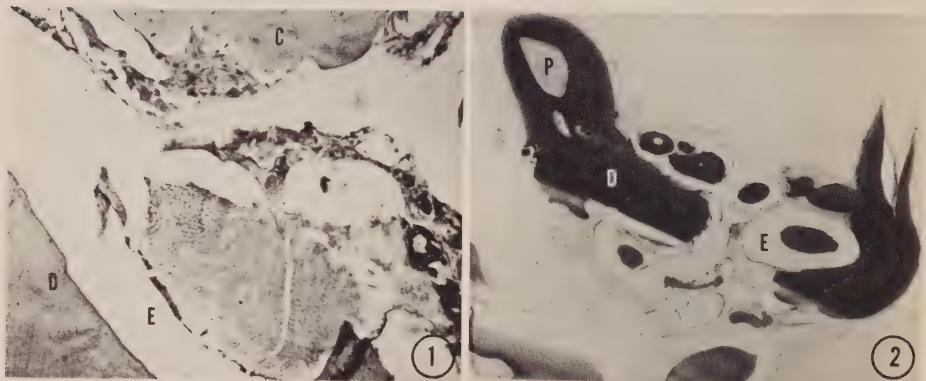
Odontomas are often found in place of a tooth or associated with a tooth.^{16, 23} Therefore, it is tempting to consider some odontomas more as anomalous teeth than as tumors.

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LEGENDS



Figs. 1 & 2
Representative Odontomas (cementum,
C.; dentin, D.; enamel, E.; pulp, P.).

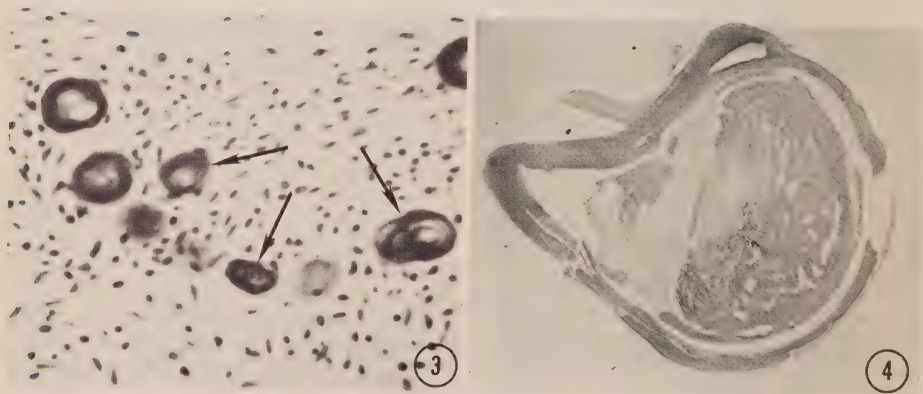


Fig. 3
Droplets of calcification (arrows).

Fig. 4
Dilated odontoma.

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Burnishing Of Amalgam: A Status Report

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Introduction

Burnishing of dental amalgam is a controversial procedure. Generally it has been considered contraindicated (Sweeney, 1944; Phillips, 1953; Skinner and Phillips, 1967; Sturdevant, *et al*, 1968). The arguments against burnishing are intuitively appealing. Sweeney (1944) condemned burnishing on the grounds that the soft material on the surface of the amalgam is pushed ahead of the burnisher and this weaker amalgam is deposited on the margins of the cavity. Warnings of excess mercury being drawn to the cavity margins by burnishing, weakening them and also making them more susceptible to tarnish and corrosion were promulgated by Phillips (1953).

These opinions, founded predominantly on speculation rather than on experimental evidence, have been propagated in textbooks of operative dentistry (Blackwell, 1955; Simon, 1956; Sturdevant, *et al*, 1968).

This paper attempts to dispel this speculation and present the recent experimental evidence which indicates that the burnishing of

amalgam is not detrimental but that it may be an important technique to decrease the incidence of marginal fracture. The discussion shall deal with several aspects of the problem: the mercury concentration at the burnished margins, the physical and metallurgical changes associated with burnishing and the corrosion potential of burnished amalgams.

Burnishing and Mercury Concentration at the Cavo-Surface Margins

The burnishing of amalgam is usually performed after carving when the amalgam has set to a sufficient degree to offer moderate deformation resistance. Does the physical deformation by burnishing of the still reacting matrix cause mercury to diffuse to margins? It is well established that mercury is brought to the surface during condensation. What occurs after the initial set has only recently been investigated.

A freshly condensed amalgam, due to the free mercury that is still reacting, gives off mercury vapor (Teixeira, Kammermeyer and Johnson, 1970). Mercury has

the property of vaporizing at room temperature which, unfortunately, is not appreciated in the dental profession. Using selenium sulfide impregnated paper, the mercury vapor emitted from the surface of a freshly condensed amalgam can be monitored to "finger print" the relative mercury concentration across the surface. Free mercury vapor reacts to form a black deposit of mercuric sulfide on the yellow-orange selenium sulfide paper. The degree of blackening is a function of the mercury concentration in the area of interest, the length of exposure time and the ambient temperature.

Teixeira, *et al* (1970) first utilized this technique in a dental application to obtain mercury printings from amalgam. Both Class V amalgam restorations and amalgam condensed into plexiglass molds were employed. Direct contact between the impregnated paper and the amalgam is prevented by insertion of a piece of filter paper. The mercury vapor easily diffuses through the filter paper to react with the selenium sulfide.

Twenty-four hour printings from carved amalgams exhibited a heavy blackening or intense printing, particularly at the marginal areas. Similar specimens burnished after carving gave printings with noticeably less darkening, this was most apparent in the marginal areas. This same trend of vapor emission was observed in polished specimens, i.e., less blackening was noted in the marginal areas of prints from amalgams carved, burnished and, after 24 hours, polished, when compared with amalgams carved and, after 24 hours, polished.

These results were confirmed in a similar study conducted by Chan and Svare (1972). Using four different commercially available amalgams, these researchers established that burnishing did not bring excess mercury to the amalgam surface. Their results indicate that, for the amalgams tested, less mercury vapor was recorded over the margins of burnished specimens when compared to carved specimens although, the authors do not make this statement as quantitation was not attempted. It should be noted that in all cases mercury vapor emission is greater from the amalgam margins than from the central portion of the specimen. This they attributed to the difficulty of applying adequate condensation pressure in the marginal regions.

Thus, contrary to popular opinion, there is no scientific evidence that burnishing amalgam increases the mercury concentration at the margins.

Physical Changes Associated with Burnishing

Several studies have been conducted concerning the effect of burnishing on the physical characteristics of amalgam.

Kanai (1966) conducted extensive metallographic studies of the margins of burnished amalgams. Investigating the matrix and dispersed phase structures, he concluded that burnishing reduced the amount of mercury (more unreacted alloy present) and greatly reduced the microporosity at the margins. This was true whether the cavities were overfilled or filled flush with the margins during condensation. This reduction in the

amount of mercury agrees with the results of Teixeira *et al*, (1970). The effect of residual mercury concentrations on amalgam is well known.

Clinical studies conducted by Nadal, Phillips and Schwartz (1961) established that high residual mercury is related to high incidence and severity of marginal fracture and surface roughness. Metallurgically, increasing the mercury concentration in a setting amalgam causes an increase in the amount of gamma₁ (Ag₂ - Hg₂) and gamma₂ (Sn - Hg₇₋₈) matrix formed. Mateer and Reitz (1971) have quantitated the reaction utilizing electron microprobe analysis. The gamma₂ phase is weak and the fracture of amalgam occurs preferentially through voids and the gamma₂ phase (Asgar and Sutfin, 1965). Thus any decrease in the amount of residual mercury will help strengthen the marginal area (Jorgenson, 1965) as will any reduction in microporosity.

Micrographs have been presented by Charbeneau (1965) which indicate reduced, more finely distributed porosity associated with burnished surfaces. In this study it was determined that surface hardness of burnished and unburnished specimens were approximately equal. This would not be the case if excess mercury was present (Alpin, Cantwell and Sorensen (1970)).

Charbeneau's Knoop hardness values were determined on embedded and sectioned specimens. The penetration of the indenter was in a direction parallel to the burnished surface rather than perpendicular to the surface. This may have influenced the results.

All the amalgam surfaces, whether carved or carved and burnished were found to have a lower surface hardness as a result of polishing. The surface of the burnished specimens was much smoother (14 vs 182 rms Microinches — profilometer measurement) and more easily polished than carved specimens. This agrees with later studies (Fusayama *et al*, 1967 and Fusayama and Hayaski, 1970). It should be noted in the scanning electron microscope studies of Fusayama and Hayaski (1970) it was found with lathe cut alloys that a very minute granular structure grew on the surface of burnished specimens after about thirty minutes. These granular prominences were sometimes observed on polished surfaces.

This is the first report of this granular structure which was not metallurgically identified nor was it analyzed by microprobe. However, these granules are so small that they are undetectable by profilometry and are not resolved by light microscopy.

The reduction in microporosity observed by Kanai and by Charbeneau has been further confirmed by Fusayama and Hayaski (1970). They found almost a complete absence of microporosity in the most superficial layers and a reduction of porosity in the near surface layer after burnishing.

The effect of burnishing on the marginal seal of amalgam restorations was investigated by Kato, Okuse and Fusayama (1968). Marginal seal was measured by dye penetration between the amalgam and the clear acrylic resin cavity form. Specimens were burnished either before carving or after carv-

ing. One group of specimens was burnished both before and after carving. Controls were not burnished at all. Twenty-four hours post-condensation, a penetrant dye was applied. All unburnished specimens exhibited marginal leakage. No leakage was observed in 50% of the specimens burnished either before or after carving. Eighty percent of the specimens burnished both before and after carving were found to have no dye penetration. These results, although impressive, are biased in that an amalgam was used which has, at 24 hours, a small negative setting dimensional change. The investigation should be repeated using various amalgams, some with positive values for setting dimensional change.

It is unfortunate that no shot impact testing has yet been conducted on burnished amalgams that could be compared with the excellent studies on carved amalgams (Gettleman *et al* 1972).

The above evidence suggests that burnishing is not detrimental to the surface of the amalgam restoration. Burnishing appears to decrease the free mercury, reduce the microporosity and help prevent leakage at the margins

Burnishing and Corrosion of Amalgam

Amalgam restorations tarnish and corrode in the oral environment. This corrosion is detrimental but in some respects may be beneficial. In time corrosion products seal the leaky amalgam marginal walls and mechanically anchor the restoration in the cavity (Mateer and Reitz, 1970). Schoonover and Souder (1941) have shown that the corrosion prod-

ucts result from the chemical dissolution of the amalgam with a concomitant loss of mechanical strength. Jorgensen (1965) has documented a theory of marginal upheaval and subsequent fracture based upon corrosion causing the release of free mercury, which diffuses into the amalgam, reacts with the gamma phase forming gamma₁ and gamma₂ which cause expansion. This is the theory of mercuroscopic expansion.

The gamma₂ phase of amalgam most prone to chemical attack (Mateer and Reitz, 1970). This is substantiated by potentiostatic corrosion studies on specially prepared amalgams in which no gamma₂ phase is present (Stoner, Lawless and Warner, 1971). Such amalgams exhibit much less corrosion in laboratory studies. Previously it was noted that high residual mercury is associated with the high gamma₂ concentrations in the set amalgam. Clinically, this correlates with the incidence of roughness, corrosion and marginal fracture (Nadal, Phillips and Schwartz, 1961; Jorgenson, 1965).

Does the burnishing of amalgam have any effect in reducing the corrosion potential of amalgam? It is known that polishing amalgam lessens the corrosion potential by removing the surface roughness which lessens the possibility of concentration cell corrosion (Skinner and Phillips, 1967). Charbeneau (1965) has shown the reduced and more finely distribute microporosity associated with burnishing. This reduction in porosity could help reduce the concentration cell corrosion.

Burnishing may reduce the mercury concentration at the margins

(Teixeria *et al* 1970; Chan and Svare, 1972), and this would result in less of the corrodible gamma phase being formed.

Svare and Chan (1972) utilizing potentiostatic anodic polarization techniques investigated the effect of surface treatment on the corrodibility of amalgam. Testing was conducted using Ringer's solution, previously shown to yield similar trends in corrosion potentials to human saliva (Nagai and Ohaski, 1967). Svare and Chan conclude that the burnished surfaces have a 60% probability of being less corrodible than polished surfaces and a 70% probability of being less corrodible than unfinished surfaces. Unfortunately, direct parallels cannot be drawn between these experimental conditions and the corrosive mechanisms operating in the oral environment, but the implication of this study is obvious. This potential study indicated that burnishing is not deleterious to the surface of the amalgam. The reduced corrosion potential observed would correlate with the reduced microporosity (Charbeneau 1965; Kanai 1966) and a lowering of free mercury at the burnished surface (Kanai 1966, Teixeria *et al*, 1970, Chan and Svare, 1971).

Summary

In the past, various arguments were advanced to condemn the practice of burnishing amalgam. The experimental data is now available which indicates that these arguments are fallacious.

What are the effects of burnishing?

Mercury vapor "finger printing" shows that burnishing does not increase the mercury concentration

at amalgam surfaces rather the results indicate reduction in mercury concentration. This reduction is most evident in the marginal areas.

Metallurgical examination confirms these findings as more unreacted gamma phase particles are present in burnished marginal areas. Further studies of the surface of burnished amalgams indicate a reduction in microporosity.

Marginal seal of freshly placed amalgams can be enhanced by burnishing as indicated by dye penetration studies.

The benefits of burnishing are most strongly indicated by laboratory corrosion studies. Polarization curves indicated that burnished and polished specimens are much less likely to corrode compared to polished specimens. These results are expected, if burnishing reduces the residual mercury and the degree of microporosity at the amalgam surface. This would help eliminate the most prevalent form of amalgam corrosion, concentration cell corrosion (Skinner and Phillips, 1967).

The evidence cited would argue for the routine use of burnishing to enhance the longevity of an amalgam restoration. Currently work has been initiated in the Department of Restorative Dentistry to study the effect of burnishing on marginal fracture as determined by shot impact tests, both before and after exposure to a corrosive environment. These experiments offer data, more clinically related, on the physical effects of burnishing. The results of this work and the methods determined for proper burnishing shall be reported at a later date.

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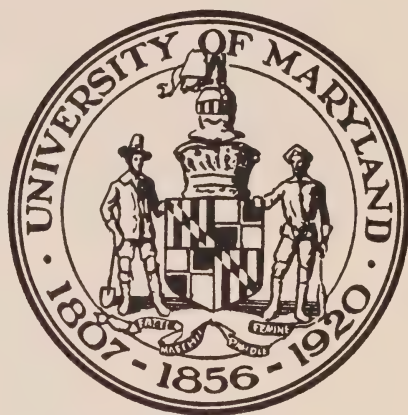
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Speech Adaptation to Dental Appliances: Theoretical Considerations

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most common (lips) involve sibilant sounds, and these sounds are also the most apt to be affected by stagefright, etc. A number of articles have described where in the mouth sibilant sounds are produced, along with general suggestions about how to fashion dentures which will permit a good phonetic result (Weir, 1932; Kessler, 1954, 1957, 1958; Martone and Black, 1962 a,b,c, 1963; Lawson and Bond, 1968, 1969). The 1969 article by Lawson and Bond contains a detailed table of effects on articulation of /s/ for specific variations in the dental arch, including details of compensations made. Unfortunately, no explanation is provided about what procedures were used to gather the information given. Other articles describe specific procedures for modifying denture design to facilitate sibilant accuracy.

- (1) Palatograms may be made with the upper trial denture to determine where the tongue is grooved in relation to the palate, and then a groove in the denture at that point is either deepened or filled in slightly. A deeper groove is necessary to correct the tendency for /s/ to sound like "th" and a shallower one is required to correct for "whistling" (Rothman, 1961).
- (2) Using palatograms made with the upper trial denture, wax is added in successive trials to those areas where tongue-palate contact is made. Additional wax is used to build up the area of the incisive papilla (Allen, 1958), a detail also stressed by Lawson and Bond (1968).

- (3) The patient is asked to speak words containing /s/ and vertical dimension is adjusted so that the inter-incisor distance during /s/ is 1-2 mm and the teeth do not click together (Landa, 1935; Mehringer, 1963; Robinson, 1969). Silverman (1956) determines "closest speaking space" in a pre-extraction test by marking on the lower teeth the level of the upper incisal edge during centric occlusion, and then observing the closest approach of the incisal edges to that line during /s/ in rapid speech. He claims that there should be no inter-incisal space visible on /s/ during rapid speaking. Cineradiographic studies of speech (Jensen, 1968; Subtelny, Oya, and Subtelny, 1972) report that the incisors approach an edge to edge position during /s/, with the lower incisors approximately 2-3 mm posterior to the uppers in persons with normal occlusion.

The choice of which words to say for making palatograms or for determining vertical dimension varied among the studies cited, and the speech sample used was not always stated. Allen (1958) asked patients to say "so," since he found that there was some tongue-palate contact on vowels other than /o/ which could have affected the palatogram for /s/. Mehringer (1963) has patients count from one to ten.

Of particular current interest in speech is the influence of phonetic context on speech acoustics, articulatory positions, and articulatory

motions. The modification of a speech sound by the presence of some feature of an adjacent sound is called co-articulation. For example, in saying "see" and "saw" the lip position during /s/ anticipates that required for the following vowel. In an X-ray study of articulatory positions for /s/ as spoken by persons with normal speech and dentition (Subtelny, Oya, and Subtelny, 1972) co-articulatory influence of adjacent vowels was observed, but it was limited to parts of the speech mechanism not critically involved in the anterior tongue-palate relationships. These investigators also found that a sustained /s/ was a good representation of /s/ in connected discourse. Although there are large individual variations in articulatory style for /s/, evidently it requires quite critical articulatory adjustments, so that there is little room for variation among phonetic contexts within a single individual's speech. These findings would seem to suggest that choice of speech sample for testing /s/ during denture fitting should not be a problem. (For other sounds to be discussed co-articulation is a major variable, so choice of speech sample becomes more critical). However, it must be remembered that the subjects in the Subtelny, Oya, and Subtelny (1972) study did not have sibilant distortions, and had their natural dentition. When phonetics is being used as an aid in denture construction, the patient may use over-careful pronunciation, and speech patterns may not be stable because of the patient's initial experimental attempts at speech adaptation. When distortion of sound is heard it is used as evidence for needed constructional changes in the denture.

Speech pathologists are aware that articulatory errors and distortions are usually not consistent, and they are careful in testing speech to obtain an adequate speech sample. There is need for a carefully thought out and prognostically validated speech task for use in dentistry.

Other sounds frequently affected by dentures are the lingua-palatal group /t, d, n, r, l/, although these and others discussed below do not represent the long range adaptation problem of the sibilants. Rothman (1961) discusses the issue of whether to include palatal rugae as an aid in orientation of the tongue, citing the opposing opinion of Slaughter (1945) and Landa (1954). Landa's view is that the additional thickness necessary may cause phonetic difficulty unless vertical dimension is increased, providing additional room for the tongue. A different emphasis stresses the importance of the occlusal plane in aiding the tongue to form the lateral seal characteristic of these speech sounds (Lawson and Bond, 1968). Lawson and Bond state that a high occlusal plane may cause difficulty in raising the tongue high enough to produce a lateral seal, thus interfering with anterior tongue mobility. If the occlusal plane is raised very high protrusion of the mandible may be necessary.

In questions of proper vertical dimension there seems to be little acknowledgment (at least in print) of the physiological contribution to achieving additional space for the tongue by increasing vertical dimension. Mandibular position must adapt to such denture changes. The tongue functions fairly independ-

ently of jaw position in speech, yet Ingervall, Carlsson, and Helkimo (1970) have shown that position of the hyoid bone is not independent of jaw position, and Perkell (1969) has described the way in which lips, mandible, hyoid bone and larynx function as a unit in speech. Since the tongue is directly connected to the hyoid bone, jaw position must provide at least a secondary constraint on tongue position. Because of its direct effect on position of the lips and larynx, jaw adjustments required by a change in vertical dimension likely have a much broader effect on speech than has been recognized.

The ease of articulation of bilabial, lingua-dental, and labio-dental sounds may be affected by vertical dimension and placement of the upper incisors. Suggested procedures for correct denture form for these sounds include providing adequate interocclusal distance so that the patient can place the tongue tip between the incisors for "th" without a sensation of biting (Chapelle, 1935), but keeping the interarch distance small enough that the lips can close easily for /p, b, m/ (Rothman, 1961). For /f, v/ consideration needs to be given to occlusal plane (Landa, 1954) and the labio-lingual position of upper incisors (Sears, 1949; Chapelle, 1935). Robinson (1969) uses the word "if" for the phonetic determination of tooth placement, which he says represents a "passive" form compared to the /f/ in "Fire!" On the word "if" the crest of the lower lip (the junction of the wet and dry surfaces) touches the edge of the upper incisors. The fact that there are different lip positions for /f/ in different words is recognized by Robinson, but he

does not associate it with a general principle of co-articulation (see MacNeilage and DeClerk, 1969).

A further and more controversial contention of Robinson (1969) is that "muscle memory" for speech gestures can be used in determining incisor placement, even though natural teeth have been lost for many years. Speech motions are to a great degree automatic in natural unselfconscious speech, and are sequenced by motor commands that appear not to depend from moment to moment on sensory feedback (MacNeilage, 1970; Harris, 1972). However, the notion that the organization of a speech motor command (underlying "muscle memory") would survive for years unaltered must at this stage of our knowledge be considered an interesting speculation.

There is limited reference in the literature to vowel changes accompanying denture insertion. Rothman (1961) cites the work of Boghosian and Spangenberg (1936) who found that the greatest alteration in vowel quality occurred on the higher vowels /i, I, e, u, U, o/, and therefore suggested that the anterior part of the denture be made as thin as possible. Rothman (1961) notes that the tongue contacts the lower teeth and alveolar processes in most vowels, as well as the maxillary molar and premolar teeth and adjoining mucosa on some vowels. Allen (1958) shows palatograms of vowels, in which there is tongue-palate contact for all but /o/. The position of contact is not really the essential feature of vowels, but rather the size and shape of the spaces in the mouth and pharynx, which deter-

mine the characteristic resonances (formants) of vowels. Lawson and Bond (1968) mention changes in resonance of the voice with dentures, but speak of resonance in a qualitative, artistic sense of carrying power of the voice. They state that a small vertical dimension may cause the voice to lose power, and thus the patient may be more difficult to understand in spite of phonetic accuracy.

RAPIDITY OF SPEECH ADAPTATION

Information on how quickly speech adaptation takes place is scattered and extremely difficult to integrate into a coherent view, because of the many factors involved. The type of dental change is one variable; criteria for determining that speech is again normal is another.

Allen (1958) found that the entire palatal vault could be filled with wax up to the margins of tongue-palate contact without interfering with speech. A 1 mm thickness of wax in the anterior region from cuspid to cuspid made speech "awkward, difficult, and indistinct." He also found that a "thin, well-adapted artificial palate (about 1 mm thick)" requires only a few minutes of practice for speech to be enunciated properly. During this practice period the /t, d, n, l/ sounds were the most awkward.

In an experimental study (Ammerman and Daniloff, 1971) four subjects were fitted with a large palatal obturator, extending forward from the maxillary second molars, and back to 2 mm beyond the fovea palatine. The volume displacement of the obturators ranged from 9.5 to 12 cc, which represents

a significant alteration in the shape and volume of the oral cavity. Subjects read sentences before, immediately after, and 5 minutes after insertion of the appliance. Experienced judges (speech pathologists) identified and classified errors as substitutions, omissions, and distortions. Immediately after insertion, subjects' speech contained a 9.35% error rate, which dropped to 6.4% in five minutes. The improvement could be attributed largely to vowel adaptation. Consonant sounds produced in the region of the obturator showed small improvement over that period of time. An important theoretical point brought out by the authors was that correctness of speech was judged in a phonemic rather than phonetic sense. In other words, even though sounds of a person's speech had to be classified as correct from a perceptual-linguistic standpoint, the sounds were still different than before the obturator was inserted.

Phonetic judgments required do not always involve speech sounds. Sim (1966) asked judges to rate vocal "resonance" (in this case, nasal voice quality) when experimental appliances 1.5, 3, and 4.5 mm thick were used to alter the volume of the palate in normal and cleft palate children. When under 30% of the palatal volume was encroached upon by the appliance, voice quality adaptation occurred easily. Girls were able to make the changes faster than boys. However, after 4 days with the thicker appliances resonance changes were still apparent.

Studies on denture patients (Troffer and Beder, 1961; Lord, 1971) indicate that speech returns

to normal by 4 weeks after denture insertion. This result was based on perceptual judgments by trained listeners, and palatographic measurements. Sherman (1970) made sets of experimental dentures for patients already wearing dentures, which were either the same in vertical dimension as the ones the patients had already adapted to, or varied in vertical dimension by ± 3 mm. The experimental dentures were fabricated to affix to a common base, which the patients were allowed to wear for a $\frac{1}{2}$ hour period before testing. Judges rated the speech on a numerical scale (1-5) representing the degree of speech distortion without reference to specific articulatory errors. Speech with any of the experimental dentures was rated worse than with the patient's own dentures, with the quality of speech deteriorating from smallest to largest vertical dimension. These results could be interpreted to mean that an increase in vertical dimension will cause the greatest speech problems, but could also indicate that in $\frac{1}{2}$ hour's time the patients adapted somewhat to the experimental bases themselves.

Results of opinion surveys of denture patients largely agree with the conclusion, above, that speech will return to normal by 4 weeks. Bergman and Carlsson (1972) interviewed 54 patients and found that 33 "began to speak unhindered" within 1 week, 11 within one month, 7 within 6 months, and 3 between 6 months and a year. Among the 77 patients interviewed by Matsuki (1971), 39.6% of patients who had previously worn dentures reported speech difficulties after 30 days, and of those who had not worn dentures previously

20.7% reported speech difficulty remaining after 30 days.

To this author's knowledge there is no study which compares external criteria of speech adequacy (listener judgments or physical measurements) with the patient's own perception of the normalcy or naturalness of his speech. That type of information is critical to determining the status of reorganization of speech motor patterns. Just because the speech sounds normal is no measure of how automatic or stable the reorganization has become. In addition, it may be possible to find evidence of subtle awkwardness in speech production even beyond the point where the patient feels speech is natural with the appliance. Robinson's (1969) statement on the persistence of "muscle memory" is relevant here.

Orthodontics has been less concerned with speech disruption than prosthodontics, since orthodontic appliances are not permanent. Also, for those who view normal occlusion as having a completely beneficial influence on speech, temporary disruption of speech patterns during treatment may not seem an important consideration. However, until we know more about the time course of speech adaptation it is risky to simply assume that an appliance present for weeks or months is purely temporary as far as speech is concerned.

OBJECTIVE MEASURES OF SPEECH ADAPTATION

Although listener judgments and perceptual phonetic analysis of speech is important for establishing naturalness of the sound of speech, there are some methodological problems with lack of agree-

ment between judges (even when highly trained). Also, the inherent subjectivity of the analysis does not give any real insight into the physical mechanism of speech adaptation. It is possible to have major physiological changes in speech activity which are not necessarily acoustically or perceptually evident.

A few studies on speech adaptation have employed physical measurements of speech, i.e., palatography, pressure of tongue-palate contact, and acoustical analysis of the recorded speech. The subjects of these studies were all denture patients.

Results of palatographic studies are somewhat difficult to compare because of differences in experimental design. In patients who had been edentulous for 6 months, Wictorin and Agnello (1970) found a greater area of tongue-palate contact for dental and alveolar phonemes after denture insertion, compared to the edentulous state. Ylppö and Sovijärvi (1962) found the same trend, but not in all subjects. Studies comparing pre-extraction patterns to those obtained after insertion of immediate dentures (Troffer and Beder, 1961; Lord, 1971) report the opposite result, i.e., tongue-palate area of contact is less with dentures. Lord is the only investigator to date to use modern electropalatography techniques to investigate speech adaptation. Electropalatography is capable of giving not only spatial information on tongue-palate contact, but temporal information on dynamic activity during speech. A review of electropalatography techniques can be found in Hardcastle (1972). Using the electropalato-

graphy system developed by Kydd and Belt (1964), Lord found that the total number of discrete point contacts returned to pre-extraction levels by 4 weeks, but the distribution of contacts suggested a more posterior tongue carriage.

In all of the palatographic investigations the speech sample consisted of single words and syllables spoken in isolation. This type of speech sample can readily be produced in a distorted or guarded manner. With electropalatography advances in recent years it is possible to record tongue-palate contacts in sentences, a potential which should be used in speech adaptation research. Although palatography is a valuable aid in studying speech activity, it does not, alone, provide sufficient information for a complete description.

Sound spectrographic analysis has been used in few studies of speech adaptation. Ylppö and Sovijärvi (1962) limited acoustical analysis to dental and alveolar consonant sounds, as spoken without teeth, with full dentures, and with maxillary or mandibular partial dentures. The patients spoke Finnish as a native language. Frequencies of frication and burst noise were lowered in edentulous and partial denture conditions, compared to when full dentures were in place. Also formant changes were seen for /l/ and /r/. These acoustical variations were used to determine which details of dentures are most essential for acoustically correct speech. Palatographic data from this same study provided some insight into the corresponding physiological adjustments made by individual patients in speaking with and without den-

tures, but no general trends could be observed.

Kaires (1957) used a single subject who had worn a maxillary immediate denture for a year. Except for some /s/ distortion, he was able to compensate readily for experimental changes in vertical dimension, e.g., reduction of 3 mm and an increase of 4 mm from the correct vertical dimension. Frication noise was found to be most intense for the correct vertical dimension, based on acoustical analysis of single words containing /s/. Pressures associated with tongue-palate contact were also measured, and found to be highest for the correct vertical dimension. The most startling finding from this study was that there was no change in spectral location of the relative amplitude peaks, both for /s/ and the adjacent vowel /I/. Since the range of denture vertical dimensions tested was 7 mm, yet the vowel formants remained unchanged, we must infer compensatory adjustments for the vowel as well as for /s/. These compensatory adjustments were such that not only was the vowel phonetically correct, but acoustically the same also.

It is generally thought that vowel production is monitored primarily auditorily, at least in comparison to consonants, since there is not as much tactile information available with a relatively open mouth position. An interesting theoretical question is whether auditory monitoring of one's own vowels is done primarily to achieve phonemic distinctions, e.g., to unambiguously say /u/ instead of something acoustically similar to it which might be confused with /o/, or whether auditory monitoring requires exact

spectral matches. Speech adaptation to dental appliances would provide an approach to answering such a question. The work of Ammerman and Daniloff (1971) and Lawson and Bond (1968) implies on perceptual grounds that only the phonemic accuracy is necessary, but the admittedly limited data in Kaires' (1957) article provides at least a reason to question that. Phonemic accuracy may only be the minimum acceptable compensation, which patients accept if they cannot do better.

As can be seen, objective information on speech adaptation is very meager indeed. Although speech adaptation appears to take some appreciable amount of time when major dental changes are made, the only longitudinal studies with objective speech measures were those comparing palatographic changes over several weeks time.

COMMENT

The process of speech adaptation does not involve a potential that lies dormant until suddenly invoked by dental changes. Speech adaptation is a normal capability of man that must be used extensively during growth and maturation. The articulatory skills of children are developed at the adult level by the age of 7 or 8—even younger in some children. Yet orofacial growth continues for another decade or more, with speech remaining normal all the while. This could not happen without considerable plasticity of function; the ability to accommodate a motor act to changing oral landmarks. The period of childhood may represent a time of special flexibility in speech adaptation, but the capability is never completely lost. The very

ability of people to speak intelligibly with cigarettes, pipes, or food in their mouths attests to the use of adaptory capabilities throughout life.

The literature reviewed above has concerned itself with changes in speech as they are manifested in specific speech sounds. Because certain elements of speech (largely sibilants) may remain defective for a considerable period of time after dental changes, research has concentrated on those phonetic elements. Should we not rather concentrate on what those patients are doing who manage successful speech adaptation?

The articulatory movements of speech, and the resulting acoustic signal, form a continuous pattern. Segmentation into contrastive phonetic units or features is a linguistic-perceptual process which underlies categorization and linguistic organization. It is difficult to define boundaries for phonetic units in physical measurements of speech. If we are to analyze changes in speech which do not disrupt linguistic organization — and speech adaptation to dental appliances would come as close as anything to

such a case — we need not be bound to linguistic-perceptual categories. In other words, speech can be studied as a patterned physiological act, which must be understood as a whole within the spatial framework of oral structural relationships.

Many research techniques exist for making physiological measurements of speech activity, without hazard or discomfort to patients, but they do require a different type of sophistication and research experience than when speech is analyzed by perceptual judgments. It is the present author's contention that the largest advances in understanding speech adaptation at this point will be gained by describing and analyzing the physical changes which the articulatory process undergoes, and then relating this to the acoustical and perceptual effects. Until we have information of this type, which can hopefully reveal patterns in speech accommodation going beyond idiosyncratic changes, our understanding of the relationship between speech characteristics and oral morphology will continue to be confounded by the phenomenon of speech adaptation.

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Anhidrotic Ectodermal Dysplasia

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Hereditary ectodermal dysplasia is a condition in which certain structures derived from the ectoderm are undeveloped or underdeveloped. This manifestation appears generally in two forms, the hidrotic and the anhidrotic.¹ Sweating occurs in the hidrotic person, while it is absent in the anhidrotic one.

The hidrotic form is transmitted by an autosomal dominant gene.¹ This appears to be largely confined to families of French or French Canadian origin.

The anhidrotic form, the topic of the present paper, is found in a variety of nationalities, ethnic groups and racial—English, French, Norwegian, Danish, German, Italian, Russian, Jewish, Japanese, Indian and Negro. Though the mode of inheritance of hereditary ectodermal dysplasia is controversial, the anhidrotic form is usually described as determined by an X-linked recessive gene. The preponderance of affected males and the absence of male to male transmission tends to support the concept that the gene is carried on the X chromosome.² Partial expression of the syndrome in presumed carriers and other members of families is observed frequently.

Hemizygotes for X-linked ectodermal dysplasia, possess consistent abnormalities in the development of hair, teeth, and sweat glands.³ Accurate genetic counseling in families with this condition is contingent upon the capacity to recognize the female carriers. Past techniques for detection of sweat gland abnormalities are unpleasant for the patient and difficult to interpret. A new and simple method, consisting of direct visual assessment of epidermal ridge sweat pores, has been devised.³ In testing, all affected males have a complete lack of epidermal ridge sweat pores, and the majority of female carriers have a paucity of them. This feature appears to be the most consistent expression of the heterozygous state.

The variability in expression of this condition in females may possibly be explained by the Lyon Hypothesis. This might account for the different modes of inheritance, since it assumes that, in females, only one X chromosome retains its heterochromatic properties and hence is probably inactive.⁴ In embryogenesis, each somatic cell of the female reaches a "time of decision" regarding whether a paternal (X^p) or a maternal (X^m) X chromosome shall be the active

participant in that particular cell. The hypothesis also suggests that there is a random determination in regard to selection of X^p or the X^m chromosome. If the inactivation of one of the X chromosomes is a random process, regarding the selection of X^p or the X^m , then a normal distribution of the proportion of cells possessing the mutant X chromosomes would be expected in a population of affected females.

Therefore, some females would possess many somatic cells with the X chromosome carrying the mutant gene and a few females would be expected to carry the active X chromosome bearing the normal allele. Most affected females are mosaics of somatic cells consisting of about 50 per cent normal and 50 per cent mutant genes on the active X chromosome.

Clinically, some females appear to be as severely affected as males with most classic features present. Others exhibit only minor manifestations of the syndrome. The findings of patchy sweat gland distribution in heterozygous females is a frequent and consistent example of the Lyon Hypothesis.

Histopathologically in addition to epidermis and dermis reduction in thickness, eccrine sweat glands are absent or rudimentary. Additionally, a thinning of the epithelial layer in the respiratory mucous membranes and hypoplasia of the underlying mucous glands may also occur.

Individuals with anhidrotic ectodermal dysplasia exhibit fine, smooth, dry skin with partial or complete absence of sweat glands, with the concomitant inability to perspire, and hyperthermia, or inability to endure warm tempera-

tures. The sebaceous glands and hair follicles are often defective or absent. The hair of the scalp and eyebrows tends to be fine and scanty resembling lanugo. In fact, the latter is often present. Nails may be normal or may show ridging, decreased thickening and slow growth.

The facial features of these individuals are so similar that even unrelated individuals appear to be siblings.⁶ Some clinicians liken the facial features to those of individuals with congenital syphilis. The bridge of the nose is depressed in a saddle-shape, the supraorbital ridge is pronounced, and the lips are everted and protuberant.

Eye defects may be present in anhidrotic individuals. Abnormalities of the lens include cataracts, subluxation, and absence.⁷ Conjunctivitis may result from the absence of lachrymation.⁷

Less common abnormalities include primary hypogonadism, hypospadias, epispadias, absence of nipples, absence of mammary glands, cleft palate, mental deficiencies, central nervous system defects, and supernumerary fingers and toes.^{1 2 8}

Petechiae and purpura are occasionally seen and tourniquet test may be positive. Koszewski and Hubbard report a 25 per cent incidence of refractory chronic anemia in patients with anhidrotic ectodermal dysplasia.⁹

Since entodermal anomalies have been shown to occur concomitant with anhidrotic ectodermal dysplasia, virtual absence of mucous glands throughout the respiratory tract and esophagus has been noted in association with this condition.⁷ Recurrent respiratory infections

may be related to this entodermal anomaly, perhaps resulting from loss of the normal cleansing and protective features of the mucosa. Mucous membranes and lachrymal glands may be defective, and chronic rhinitis contributes to the development of the saddle nose.⁷

There is often a high prevalence of allergic diseases such as extrinsic bronchial asthma and flexural exzema. Positive prick test reactions to common inhalents and food allergies occur in patients with anhidrotic ectodermal dysplasia as compared to those found in the general population.⁷ The explanation for increased prevalence is not clear at present, and several hypotheses have been proposed.

Some other defects noted include intermittent fever, temperature rise after meals, hyperpyrexia, headaches, increase in pulse and respiratory rates in warm environments, polyuria, alkalosis from hyperventilation, decrease in the sense of taste and smell, and malodorous nasal discharges.^{1 2 8}

The dental findings in anhidrotic ectodermal dysplasia are of particular interest, since patients with this abnormality invariably manifest complete or partial anodontia without impairment of mandibular growth.¹⁰ Furthermore, the teeth are commonly truncated or cone-shaped.

Although it might be expected that the salivary glands would be involved by anhidrotic ectodermal dysplasia, this is not necessarily the case, since the individuals affected do not ordinarily complain of xerostomia; however, the lips may be dry and cracked.

Cephalometric radiographs are an excellent aid in appraising fa-

cial balance, facial type and harmony of external features.¹¹ The most prominent features in the lateral headfilms used in cephalometric analysis are the lack of vertical alveolar development and the prognathic skeletal profile.¹² Evident prognathic factors are the anterior placement of the glenoid fossa, elongated mandible (including a large pogonion prominence), large gonial angle, and short (anterior-posterior) maxilla. These prognathic features are tempered by the fact that the maxilla is placed a considerable distance anterior to the sella tursica.

The clinical diagnosis in early infancy may be difficult since affected individuals often appear normal at birth, the characteristic facies not being evident until about the eleventh month.¹⁰ Roentgenologically, however, the diagnosis can be made on the first day of life, since the crowns of the primary incisors are radiopaque by the fifth and sixth fetal month, and all of the primary teeth are calcified by birth.¹³ In early infancy, an unexplained fever, directly related to high environmental temperatures, may provide a clue to early diagnosis. At this time confirmatory diagnostic evidence can be secured from a radiograph of the jaws. Often a delay in diagnosis can result in prolonged convulsions possibly leading to pronounced brain damage.¹⁴

No definitive treatment for anhidrotic ectodermal dysplasia exists; though treatment of symptoms relating to the ectodermal dysplasia are not uncommon. The recognition and treatment of some symptoms, especially high fevers, are essential if seizures and brain damage are to be prevented.¹⁴ Fur-

thermore, direct exposure to hot sun, high environmental temperatures and violent exercise should be avoided.⁸

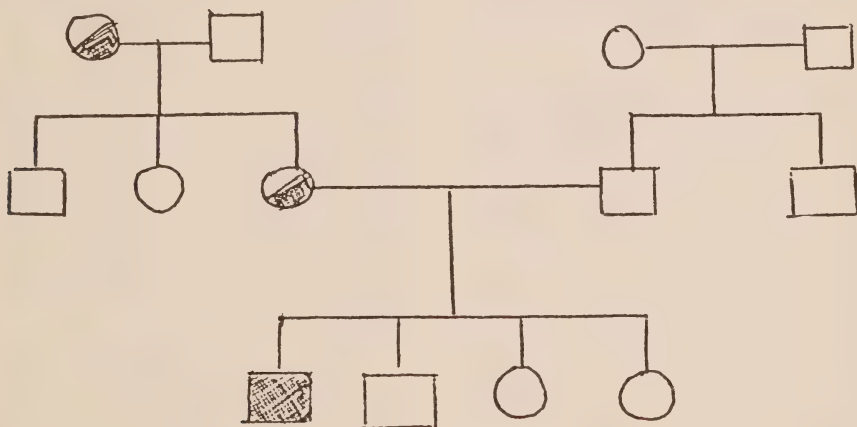
Anodontia presents a severe problem to both the patient and the dentist, and the need for some type of transitional therapy is essential since this condition becomes evident at an early age.¹⁵ In addition to considering the developmental and functional phases of treatment, the dentist must be aware of the psychological development of the patient. It is often a traumatic experience, particularly for individuals in their teens, to face their peer groups with an esthetically displeasing dentition.

Certain defects in ectodermal dysplasia, namely the saddle nose, the sunken dishpan face, and the occasional ear anomalies, are amenable to reconstructive surgery, and these corrective procedures frequently provide a tremendous psychological boost for these patients.¹⁶

Ear manifestations may vary from slight alterations of auricular configuration to pointed satyr ears. The latter may be corrected by otoplasty. Further defects, such as the short, sparse scalp due to a reduced number of active hair follicles, may be overcome either by the new transplantation techniques, or even more successfully by a wig or hairpiece.

A patient (seven year old black male) was referred to the University of Maryland Dental Clinic because of partial anodontia. His history revealed that he was the product of a normal pregnancy and delivery, and that during the neonatal period, he often experienced unexplained high fevers. These fevers continued through the first several months of his life, and were often accompanied by a nasal discharge. His mother increased his fluid intake to reduce elevated temperatures.

At two years of age, his mother



shaded = affected
 non-shaded = non-affected
 half shaded = partial expression

became concerned that he had acquired but one tooth. Clinical examination revealed the possibility of hereditary ectodermal dysplasia.

Upon interviewing the patient's parents, sufficient data was obtained to draw a pedigree.

The patient's mother relates that though she "suffers from the heat," she experiences limited perspiring. The maternal grandmother of the patient, was described as a woman with extremely thin hair, no eyebrows, and a few pointed teeth. She was known to have an intolerance to hot weather. All other members of the maternal side of the family were described as normal. The father, and the paternal side of the patient's family, were also described as normal.

It may be concluded from the information obtained that both the patient's mother and grandmother are female carriers of anhidrotic ectodermal dysplasia. There is a variability in their expression, according to the Lyon Hypothesis, with a greater degree being prevalent in the grandmother.

The patient possesses the characteristic appearance, and many of the more common feature manifestations of the disease. He was born with no hair, and later developed blond hair which has been turning darker over the years. The hair has the texture of lanugo, quite different from the coarse hair prevalent in blacks. He has a saddle-shaped nose, and the classically shaped pointed teeth. His lips are protuberant, and his lower lip appears to be everted. His nails do not show atrophic changes and his skin is extremely dry. He suffers a great deal in hot weather and drinks large amounts of liquids. The pa-

tient is hyperactive, and has had episodes of sudden collapse due to heat prostration. He has been known also to have frequent nose bleeds especially during the summer months. Annual eye examinations reveal no abnormalities; however, he has had conjunctivitis on many occasions. The patient is allergic to many agents both of the airborne and the food variety, and during the spring and summer months, he is quite uncomfortable due to these allergies.

Approximately two years ago a pair of partial denture appliances were designed and fabricated for the patient to replace his numerous missing teeth. His parents were anxious for these appliances to be made, but he was not eager for them. After they were inserted, the patient resisted wearing them and eventually broke them. A second set of dentures were then made for him. Not long after receiving them he reported their loss. After continued interrogation by his mother, he admitted that he had thrown the dentures into a wastebasket "on purpose."

After this episode, it was decided that new dentures would not be made for him. It was felt that eventually he would either become self-conscious of his teeth, or that he would be teased by other children about them. It was thus decided that new dentures would be made for the patient only when he desired them himself.

Recently, the patient's mother contacted the author to state that the patient had made his decision. He has returned to the dental school and is now having a new pair of removable denture appliances designed.

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Figure 1.

Photograph of patient denoting the saddle-shaped nose and the everted and protruberant lips.

Figure 2.

Note the fine, scanty lanugo-type hair on the back of the patient's head.

Figure 3.

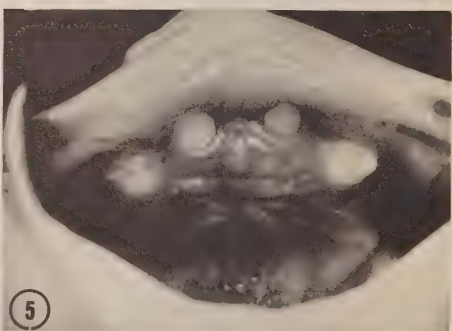
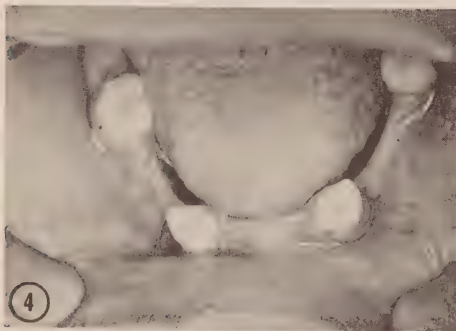
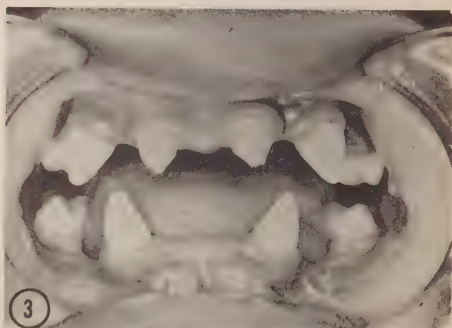
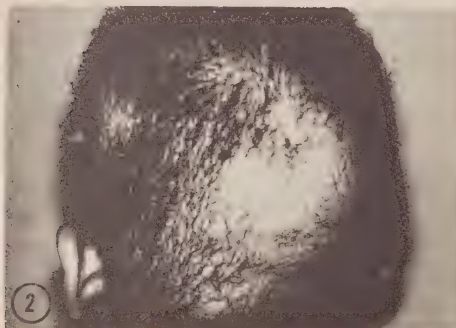
Observe the partial anodontia and the cone-shaped incisors.

Figure 4.

Note the lack of alveolar development in the mandibular arch.

Figure 5.

Observe the marked melanin pigmentation on the palate.



Evaluation of Drug Utilization by Dental Patients

II. Drugs Prescribed by Dentists in Private Practice for Home Use

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Evaluation of Drug Utilization by Dental Patients

II. Drugs Prescribed by Dentists in Private Practice for Home Use

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SUMMARY

Medications prescribed by practicing dentists in the Baltimore metropolitan area to patients for home use have been evaluated through a random survey of prescriptions dispensed in pharmacies throughout the area. Dental prescriptions accounted for 1.6% of all prescriptions surveyed, and were written by 27% of the total practicing dentists. Four therapeutic categories consisting of narcotic analgesics, penicillin antibiotics, non-narcotic analgesics and non-penicillin antibiotics represented 94.2% of all dental prescriptions. The drug product most frequently prescribed was penicillin V (22.0%) and the trade name and strength most frequently written was V-cillin K 250 mg (14.0%).

Two hundred and seventy patients received two or more prescriptions simultaneously. General practitioners accounted for over 79% of dental prescriptions while oral surgeons accounted for approximately 12%. All other dental specialties accounted for less than 9%.

INTRODUCTION

No drug is free of producing some type of adverse effect in a certain number of patients. Consideration of this problem is necessary in order to intelligently practice dental therapeutics. It has been estimated that about 5% of the annual hospitalized patients in the United States are admitted due to adverse reaction to drugs,¹ with some hospitals reporting incidences as high as 20%.²

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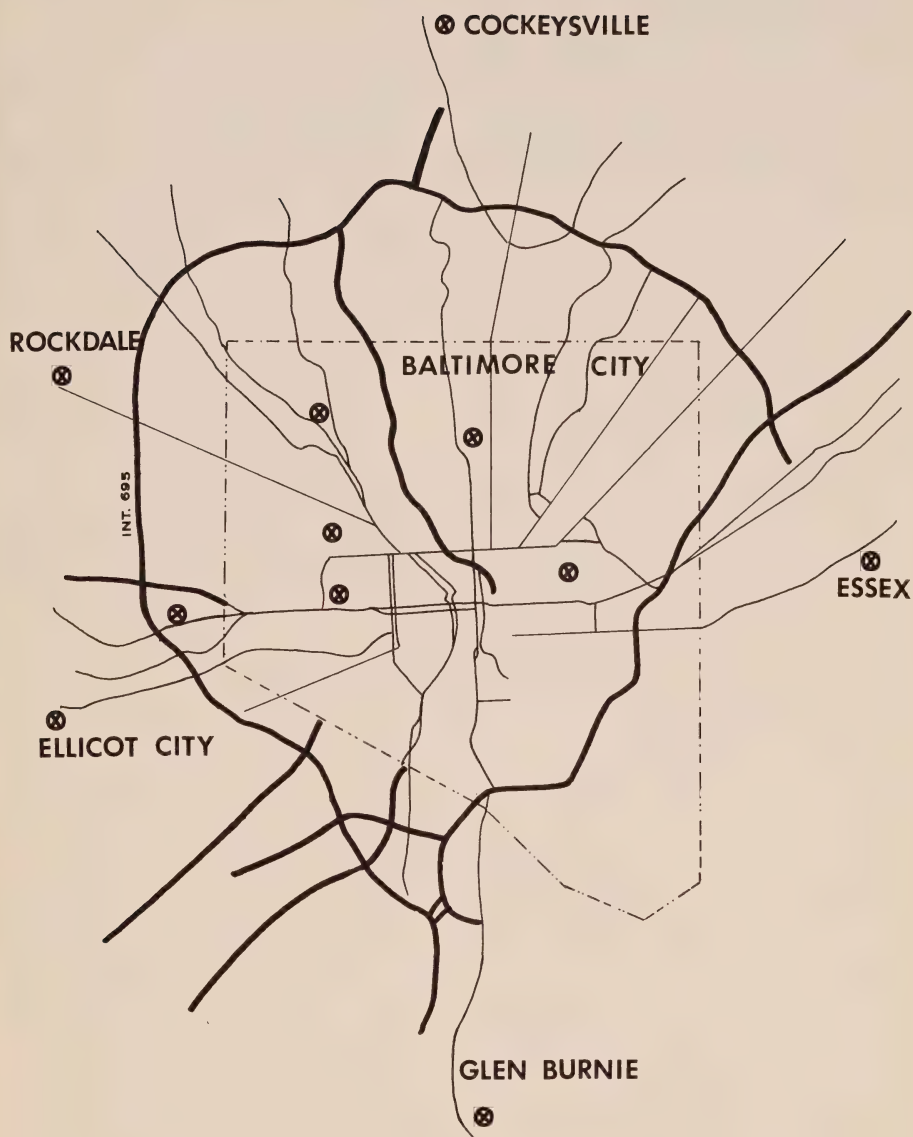


Figure 1. Unbiased location of pharmacies used in survey.

It is quite obvious that the incidence of adverse drug reactions in a dental patient population will increase as increasing amounts of medications are prescribed. New prescriptions written by dentists in 1969 were twice as many compared to 1962,³ and the frequency and amounts of medications prescribed are likely to continue to increase in the future.

Knowledge of drug usage by dental patients can be utilized to prevent and monitor adverse drug reactions. A series of studies are currently in progress to evaluate premedication administered before dental treatment, ancillary medication used during treatment, post-medication for home use and medication obtained from other sources. A previous report evaluated medications prescribed in a dental clinic for home use.⁴ This report concerns those medications prescribed by

dentists in private practice to a dental patient population for home use.

METHODS

Medications were surveyed from prescriptions dispensed and filed in pharmacies located in the greater Baltimore area. Pharmacies were chosen at random using a list of random numbers for selection from a most recent yellow pages of the Baltimore metropolitan telephone directory. Randomization produced an unbiased selection of pharmacies, the locations of which are indicated in Figure 1. Prescription files of each pharmacy were surveyed until approximately 100 dental prescriptions were accounted for. The prescriptions were evaluated according to therapeutic category of the prescribed medication, specific products and trade names and strengths. The total number of dental prescriptions were evaluated

TABLE I
Therapeutic Categories of Prescriptions
Written by Dentists in Private Practice

Rank	Category	No.	%
1	Analgesics: Narcotics.....	396	31.9
2	Antibiotics: Penicillins.....	361	29.1
3	Analgesics: Non-narcotic.....	218	17.6
4	Antibiotics: Non-penicillins.....	194	15.6
5	Fluorides.....	10	0.8
6	Enzymes: Proteolytic.....	9	0.7
7	Hormones: Corticoids.....	9	0.7
8	Tranquilizers.....	8	0.6
9	Vitamins.....	4	0.3
10	Miscellaneous.....	33	2.7
TOTAL.....		1242	100.0

according to the prescribers' dental specialty.

RESULTS

Of 76,000 prescriptions surveyed, 1242 (1.6%) were written by dentists. These prescriptions accounted for 27% of the total privately practicing dentist population in the Baltimore area. Total medications prescribed represented at least ten therapeutic categories (Table I). Narcotic analgesics were prescribed most frequently (31.9%) while penicillins, non-narcotic analgesics and non-penicillin antibiotics ranked 2nd, 3rd and 4th respectively. These four categories represented 94.2% of all medications prescribed.

Evaluation according to products (Table II) indicated penicillin V preparations to be most frequent (22.0%) with Darvon and Empirin Compound w/codeine preparations in a close second and third respectively. As few as five products represented 67.3% of total medications prescribed. Evaluation according to trade names and strengths (Table III) indicated V-cillin K 250 mg to be most frequently

prescribed (14.0%) with Empirin Compound w/codeine 30 mg a close second (13.5%). Ten trade names represented 64.0% of all prescribed medications.

The sources of the dental prescriptions evaluated included six specialties. General practitioners accounted for 79.3%, oral surgeons 11.7%, periodontists 3.7%, orthodontists and pedodontists 1.9% and endodontists 1.2%.

DISCUSSION

The ten therapeutic categories of medications observed in this study were very similar to the leading ten therapeutic categories of new prescriptions written by practicing dentists as reported in a national survey³ and to the leading ten therapeutic categories written in a dental clinic.⁴ The top four categories (narcotic analgesics, penicillin antibiotics, non-narcotic analgesics and non-penicillin antibiotics) accounting for 94.2% of prescriptions, compared favorably to the same four categories which were 88.1% nationally and 97.0% in the dental clinic.

TABLE II
Leading Products Prescribed by Dentists
in Private Practice

Rank	Product	No.	%
1	Penicillin V preparations.....	273	22.0
2	Darvon preparations.....	184	14.8
3	Empirin Compound w/codeine preparations.....	179	14.4
4	Phenaphen w/codeine preparations	130	10.5
5	Erythromycin preparations.....	69	5.6
PERCENT SHARE OF TOTAL PRESCRIPTIONS....			67.3

Differences were observed by products. Darvon preparations ranked first nationally while penicillin V preparations ranked first in the present study. Differences were also observed according to trade names and strengths. Whereas Darvon compound-65 and Empirin Compound w/codeine 30 mg ranked first and second respectively in the national survey, V-cillin K 250 mg and Empirin Compound w/codeine 30 mg were numbers one and two in this study.

A recent study identified 108 therapeutic drug interactions in 60 medical patients taking prescription medications.⁵ Therefore observations on the number of patients

receiving two or more prescriptions is of interest since information concerning multiple drug therapy can be used in the screening and prevention of drug interactions with the use of drugs in dentistry.⁶ Two hundred and seventy patients were observed to have received two or more prescriptions simultaneously. In no case however, were any of the combinations observed to have a potential for interaction in the patient.

This study has presented continuing data obtained from a series of studies currently in progress. Future reports will be concerned with other aspects of dental patient drug utilization.

TABLE III
Leading Trade Names and Strengths Prescribed
by Dentists in Private Practice

Rank	Trade Name and Strength	No.	%
1	V-cillin K 250 mg	174	14.0
2	Empirin Compound w/codeine 30 mg.	168	13.5
3	Darvon Compound 65 mg.....	116	9.3
4	Phenaphen w/codeine 30 mg.....	114	9.2
5	Pen Vee K 250 mg.....	64	5.2
6	Cleocin 150 mg.....	49	4.0
7	Darvon N w/ASA.....	35	2.8
8	Erythromycin (Generic) 250 mg.....	31	2.5
9	Ampicillin (Generic) 250 mg.....	26	2.1
10	Demerol 50 mg.....	17	1.4
PERCENT SHARE OF TOTAL PRESCRIPTIONS..			64.0

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**Osteogenesis Imperfecta and
Dentinogenesis Imperfecta:
Report of a Case**

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Osteogenesis Imperfecta and Dentinogenesis Imperfecta: Report of a Case

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Osteogenesis imperfecta is a disease manifested by increased fragility of the bones, which are easily fractured by slight trauma. Patients usually have blue sclera, flaccid ligaments and deafness in later life.⁸ Osteogenesis appears in two forms, congenita and tarda, however this division may only represent a variation in severity and time of its clinical expression.

Osteogenesis imperfecta is familial and appears to be dominant autosomal, but is extremely variable in phenotypic expression. Several of the associated variations in development may be present in the same family or in any one member.⁵

Other names for osteogenesis imperfecta are fragile bones, brittle bones, Lobstein's disease, osteospathyrosis idiopathica, Van der Hoeve-de Kleyn Syndrome.^{5 8 9}

The basic defect is in mesenchymal tissues. It is characterized by the failure of the reticulum to differentiate into mature collagen as demonstrated in the corium, sclera, and cornea.³ Bone matrix is not produced and results in defective

formation and differentiation of subperiosteal and endosteal bone. The calcification of bone matrix appears to proceed normally. In some, the osteoblasts are normal in number but don't function, in others, they are reduced in number or absent.⁵

The congenita form of osteogenesis imperfecta is severe and is manifest by many fractures, especially the ribs and lower extremities. These fractures often occur in utero. If the infant survives, he may not walk or may be dwarfed in stature with normal trunk proportions and short extremities. When severe, the child is stillborn.

In the tarda form there is great variation in time of first fracture. It may be so severe as to resemble the congenita type. The bones of the extremities are long and slender, with most fractures occurring in the legs. Healing is rapid, but deformities may develop. Blue sclera are generally present, while deafness is only seen in one-fourth of the cases and is a late manifestation. A clear distinction between

tarda and congenita is often difficult.⁸

Roentgenographically, the diaphysis is diminished, and a radio-lucency of the cortex and a scanty spongiosa are present. Shafts of long bones are narrow with flaring ends. There is an irregular mineralization of calvarium with mosaic rarefaction. The skull undergoes dimensional changes such as occipital overhang and frontal bossing.⁵ Although the mineral content of the bones seems reduced, the bone age usually corresponds to the child's chronological age.⁸

Deafness is due to otic capsule involvement. Sclerosis produces a bony ankylosis of the stapediovestibular joint. This impairs the transmission mechanism for sound. In addition, the skull deformities may alter the position of the tympanic membrane. This deafness is not treatable.⁵ Opheim⁹ investigated five cases and found parts of the stapes crura to be degenerated into thin fibrous threads in four of the five cases. These findings were also reported by Hall and Rohrt⁴ after examining newborns who died on the twenty-fifth day of life with multiple fractures of arms, legs and costae, soft calvarium, and blue sclera were reported.

Children that do not die after birth become severely deformed. This can be lessened with orthopedic treatment. The prospect of developing deafness and transmitting the disorder to offspring must be considered as part of the prognosis. There is no effective treatment, however the affected must be protected from trauma and maintaining good nutrition is essential.

Dentinogenesis imperfecta is often a complication of osteogenesis imperfecta. Another name for this anomaly is hereditary opalescent dentin. It is the most prevalent hereditary dystrophy affecting tooth structure.² Witkop¹² found the prevalence to be one child in 8000. The teeth can appear gray to blue-brown, pink or yellow in reflected light, and they are highly translucent.^{2 5 11} The enamel organ is normal, but the odontoblasts that are present don't function normally. The dentin is soft and subject to rapid attrition, often becoming level with the gingival margin. The dentino-enamel junction may lack the scalloped microscopic appearance of normal teeth. This smooth junction allows enamel to fracture easily and increases the rapid attrition of the teeth.^{2 5 6 11} The teeth have a low susceptibility to caries although the tremendous destruction of the crown simulates the caries process.² Witkop¹³ reports that primary teeth, permanent first molars and incisors are affected severely, while the permanent cuspids, bicuspid, and second molars may be less damaged.

On roentgenographic survey a characteristic decrease in root size is noted, the root ends are spiked, and the pulp chambers are often absent and the canals partially or completely obliterated. The cementum, periodontal ligament space, and alveolar bone all appear normal.^{2 3 5} Microscopically, the dentinal tubules are obliterated and occluded. They have an irregular direction and configuration. The cementum and enamel are normal.⁵

Dentinogenesis imperfecta is inherited as an autosomal dominant trait. In certain instances, there is

incomplete penetration and this accounts for the occasional skipping of a generation. It is manifest during the developmental period of histodifferentiation.²

The loss of tooth structure resulting from this condition can be restored with stainless steel crowns or full dentures. This prevents further attrition. The stainless steel crowns can be replaced by more esthetic prostheses later.²

Witkop reported his findings of dentinogenesis imperfecta in a group of Brandywine isolates.¹² They were unassociated with bone disease, blue sclera or any other stigmata of osteogenesis imperfecta. There was no increase in bone fractures and no cases of osteogenesis imperfecta were found in the isolate.

An analysis by Witkop¹² of the fertility of persons affected with dentinogenesis imperfecta shows that differential fertility of affected males compared with their unaffected siblings contributed significantly to the apparent increase in frequency of this trait by generation.

Sobel¹⁰ describes a 4½ year old caucasian male with a graying of the primary teeth. His father, paternal aunt, and female cousin had similar disorders. Physical exam was within normal limits, and radiographs revealed wide pulp canals in the cuspids, partially obliterated canals in the lower centrals and lower right first molar and lower left second molar. Areas of internal resorption were seen in several teeth and a pulp stone was observed. Lynn⁷ reported a case of osteogenesis imperfecta with nu-

merous fractures of the long bones in a female who had undergone full mouth extractions.

CASE HISTORY—A happy, well nourished, extremely outgoing five year old caucasian male reported to the University of Maryland Pediatric Dental Clinic with a chief complaint of "worn down teeth that had no calcium on them." In addition, he had difficulty in chewing.

His past medical history revealed a history of osteogenesis imperfecta. The patient was deformed at birth due to multiple fractures and had a history of chronic kidney infection. He had the usual child diseases; including varicella, rubella, parotitis, and rubeola. In addition, his mother reported frequent tonsillitis and ear infections. His previous hospital admissions were in 1967, at age 1½ years for treatment of both right and left femur, tibia, and fibula fractures, in 1968 and 1969 for treatment of respiratory infection necessitating oxygen therapy for three days.

The patient's present height was 35½ inches and his weight was 47½ pounds. His weight was at the 75% level for his age, while his height was well below the 3% level for five years old (75% level is 47 inches).

The patient's gait was irregular, in that his trunk moving from left to right in an exaggerated fashion with each step taken, while his knee appeared to lock in place to maintain balance. He could not walk at normal speeds.

In a review of systems, his ears were frequently infected, and his

teeth severely abraided with several chronic abscesses of anterior teeth. He has a good appetite, but he vomited easily. He lives in a suburban environment and plays outdoors frequently, getting along well with other children and adults.

A family history revealed a healthy mother, age 26 years with a history of coarctation of the aorta which was surgically corrected in 1964. One prior abortion was performed due to difficulty in carrying the fetus. The father was 26 years old and healthy. One sibling, a four year old sister, was healthy with no significant findings. A paternal uncle was affected with trisomy 21. Diabetes was present in both the mother's and father's family—a maternal grandmother and aunt and a paternal grandmother. An attempt was made to trace the osteogenesis imperfecta by pedigree, but no conclusive information was determined.

A detailed dental exam with radiographs was performed. A mixed dentition was observed with exfoliation of the mandibular primary central incisors, and left lateral incisor, and maxillary left central incisor. The eruption of the mandibular permanent centrals had clinically started (see figures 2, 4, and 5). The remaining primary teeth were abraided to the gingival margins with almost complete loss of enamel except for all four primary second molars (see figure 3). These teeth had just begun to abraid and still had enamel remaining. Several of the anterior teeth revealed chronic abscess formation. There were no caries detected on any tooth surfaces (see figures 2 and 4). The roentgenographic survey revealed an obliteration

of the pulp chambers and root canals of all primary teeth. The periodontal ligament space appeared normal and the permanent teeth were developing as expected.

Due to the patient's apprehensive response to dentistry, the large amount of work to be done, and the great distances traveled to reach the University of Maryland Clinic, the dental treatment was performed under general anesthesia in the operating room. The abscessed primary anterior teeth were extracted and stainless steel crowns were placed over the remaining primary cuspids and molars. Then maxillary and mandibular partial dentures were constructed to enable the patient to eat properly, and to improve his speech, and his facial appearance.

DISCUSSION

The case reported illustrates the characteristic findings of hereditary dentinogenesis imperfecta. The teeth were highly translucent, the dentin soft and teeth were worn to the gingival level. Microscopically the dentino-enamel junction lacked a scalloped effect, and roentgenographs revealed decreased root size and obliterated pulp canals.

In addition to the dental findings this patient also exhibited the characteristics of osteogenesis imperfecta. Many of the bones of the extremities had multiple fractures at birth, blue sclera were in evidence and the child had frequent ear infections.

The hereditary pattern in this case does not coincide with the typical findings of dominance with no sex linkage. However this may be a case in which there was in-

complete penetration and several generations were skipped.

SUMMARY

Osteogenesis imperfecta and dentinogenesis imperfecta were discussed. Findings of previous investigators were reported. A case report was presented along with the treatment rendered, in order to illustrate some of the more common findings of this condition.

Acknowledgements

I would like to thank Dr. Stephan Levin of the Moore Clinic, Johns Hopkins Hospital for his cooperation in taking follow-up photographs.

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Figure 1

Patient with Osteogenesis imperfecta and Dentinogenesis imperfecta—Age 5 years.



Figure 2

Dentition of patient in Figure 1. Marked attrition of crowns of primary teeth.



Figure 3

Maxillary arch of same patient. Marked attrition of primary teeth, with a translucent appearance.



Figure 4

Permanent mandibular central incisors. Note characteristic translucency seen in Dentinogenesis imperfecta.

Figure 5

The same child, teeth restored with stainless steel crowns.

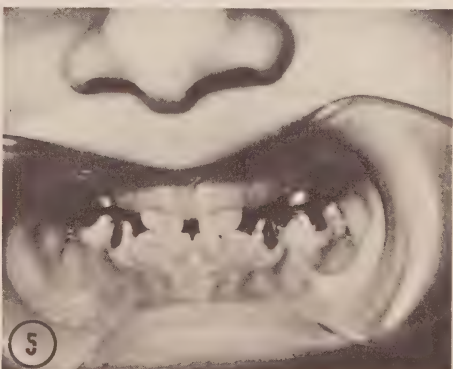
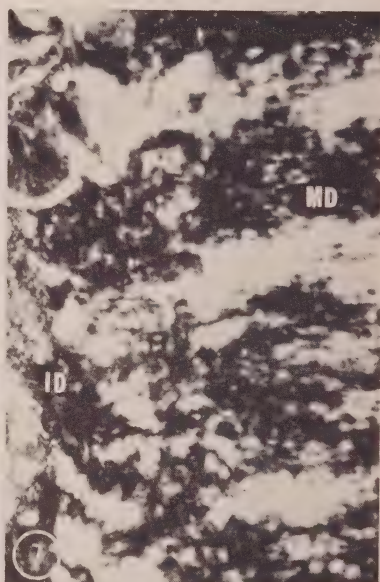


Figure 6

Photomicrograph of ground section of tooth. Original magnification 50 X. Polarized light. Note the irregular dental tubules. M. D.—Mantle Dentin. I. D.—Irregular Dentin. P.—Pulp.

Figure 7

Photomicrograph of ground section of tooth. 125 X. Showing irregular dental tubules. M. D.—Mantle Dentin. I. D.—Irregular Dentin.





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"On the Matter of Discussing Things"

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"On the Matter of Discussing Things"

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Dean Salley, members of the faculty and the student body, and guests—I am honored to have been selected as the Powell lecturer for 1974. The lectureship has achieved national recognition by virtue of the quality of the presentations made in years past; and, it represents a formidable challenge to one who accepts the opportunity. It is indeed difficult to say something which is sufficiently profound and well structured to meet the standards which have been set. Nevertheless, I am here and I hope what I have to say will be of interest to you and sufficiently thought provoking to have been worth your time.

Before beginning on the substance of my comments, I wish to recognize the University of Maryland School of Dental Medicine for its long and outstanding contributions to the field of dental education. Particularly in recent years has the administration, faculty and student body of this school assumed a position of important leadership. Capitalizing on your fine new facilities, and improved budgetary resources, the school has developed many innovative efforts while sustaining high quality in its educational programs. Such accomplishments require imagination, dedication, and a spirit of en-

thusiasm which this institution obviously projects. May I extend my warmest congratulations, and best wishes for continuing excellence and progress in your wide range of programs.

I am compelled to comment on one setback your institution seems to have suffered recently. I refer to the evidence which has been uncovered to the effect that Doc Holiday apparently graduated from the University of Pennsylvania instead of this school. I can tell you that you shouldn't feel too badly about that. In the late 1950's I conducted a general practice in the town in Colorado where Doc Holiday died and is buried. I even had some older patients who remembered him from their childhood. They told me that most people were relieved at his passing since the presence of the Doc and his associates in town made folks quite nervous and unhappy. He couldn't have been too bright as he sought out Glenwood Springs to sit in its natural steam caves in an effort to cure his tuberculosis—a form of therapy which merely hastened his demise. Those of us who practiced there had to put up with a constant barrage of bad jokes about how Doc Holiday had been the first dentist in town and the quality had not improved noticeably since. You

should be happy to pass credit for the graduation of that notable alumnus to the University of Pennsylvania.

I suppose that one of the reasons I was selected to present this lecture today is the fact that I am nearing the end of an eight year tenure as Dean of a dental school which, I gather, has a reasonably good reputation; and, that during the course of this experience, I have had an opportunity to view dental education, dental practice, and organized dentistry in the broad context. Some of these associations have been intensive and others less involved. Actually, my twenty years in the dental profession have included two years in full time general practice, a two year hitch in the Navy Dental Corps, advanced education in a dental specialty and conduct of a private practice in that specialty, study of a basic science discipline, experience as a clinical and basic science teacher in dental education, conduct of an active research program, experience as a dental school administrator, and various memberships and consultantships on committees of Federal, State, and non-governmental agencies. I am not trying to impress you with my credentials, but merely explain that I have seen dentistry and dental education from a number of viewpoints. Regardless of my background and experiences, I am sure that you will make your own judgment about the validity and import of my observations. With those introductory comments, I'll get on with the major business of my presentation. I would like to discuss today the matter of how a profession and the members of that profession might go about

discussing their business and how intelligent decisions might be reached.

First, I would like to begin by advancing a major philosophical position and then extrapolating that concept into the profession of dentistry and dental education to see how it is faring in our discipline in these times. The basic precept I wish to advance is simply that creative thought is the vehicle of human progress, and that, without unstifed creativity and exploration of new and better ways of doing things, a society is doomed to stagnation and disintegration.

Ever since mankind descended from the trees to stand erect on the ground, and find his environment there, he has made continuous progress in the quest to improve his lot. He has risen from the status of an animal to a condition of sophisticated thought and some relative control over his destiny. Through the centuries he has sought out and explored better ways of doing things, and has continuously improved the human condition in terms of physical health and well being, social justice, and productive use of the resources provided to us by nature. Not always has the progress been steady. In fact, in some periods of our history it has been temporarily regressive. Nor has it always been properly directed. But, the general trend has been a positive one such that the good old days of any era do not really stack up with the comforts and opportunities available to most of us today. This observation takes into account our current energy crisis and all it implies, but I am convinced that this episode will merely be the

much needed stimulus for an adjustment in the direction of our quest for progress and the development of new and better means to provide mankind with the sources of energy he needs which will be compatible with his environment.

I believe such progress will continue indefinitely. I believe that simply because such has always been the case. Man has an insatiable desire to solve his problems and create better conditions for himself. He may make some mistakes and he may be temporarily impeded, or set back, in his progress; but, he is most certain to succeed over the long run. If one does not adhere to that thesis, he really has very little reason to live, and I would think that his life would be dreadfully unexciting and uncreative.

If you are willing to agree with me on this basic concept, there are several aspects of it which I would like to explore with you. The first point is that creative thought and progress are based on the quest for knowledge and the seeking of truth. The manner in which real progress is achieved is through the creation of a new idea (a thesis, if you will), careful and objective study of that idea, conclusions drawn from factual data, and application of these conclusions to the problem at hand.

The first requirement is creative thought. New ideas must be constantly stimulated and given free expression. I would like to place special emphasis on this matter of freedom of expression. By that I mean that an individual should be able to express an idea,

even one which threatens considerable change, and have responses developed to that idea without being subjected to personal attack, particularly of the character assassination variety. Similarly, the person who proposes the idea should not regard those who subject that idea to criticism and comment as unmitigated reactionaries or irrational people. Until solid data are available, the thesis should be represented as only that—a thesis. Those who criticize it without documentation should make it clear that their observations are only speculations and are equally subject to error.

Once the idea or thesis has been advanced, it must then be examined in the most objective and scientific method possible. I am a great believer in the scientific method when its principles are strictly applied and its results properly used. The careful structuring of a thesis, development of accurate methods of obtaining data, and the application of proven methods of statistical analysis provide us with our greatest hope of obtaining objectivity and true factual data.

Once the data become available one must be very careful about the conclusions which can be reasonably drawn from such information. There should be careful avoidance of extrapolation where it is not warranted. The conclusions should be applied to situations where they fit. When this is done, opinions are replaced by fact and sound decisions can be made.

Now, all of this seems rather elementary. It is the system by which our most important scien-

tific and technological advances have been made through the years. It would seem to be only common sense that it be applied in any arena where new ideas are forthcoming and need to be tested. However, I fear that our profession is not utilizing this approach to the introduction and investigation of new ideas in an optimal manner. In fact, I find that emotionalism, undocumented opinion, and highly personal attacks have often occupied the center stage of our deliberations in the place of objective research and consideration based on information derived through careful investigation. It seems to me that far too often the introduction of a new idea brings to its presenter an avalanche of negative comments about his politics, concern for dentistry as a profession, and even the nature of his parentage. I have also seen people who have advanced a new thesis, and had it subjected to criticism, strike out at their detractors in a similar manner. Under such circumstances the idea which has been brought forth for consideration has little hope of being subjected to scientific and objective consideration. New thoughts are either stifled at the outset or investigation of them suppressed because people fear that objective evaluation will produce results which are contrary to their own opinion. On the other hand, some of these theses are advanced as being supported by sound evidence when such is lacking, or that the need for such evidence to support the thesis is not necessary.

My personal experience with some of these episodes has been particularly disconcerting. The thought that a major University

would not be permitted to structure and carry out an experiment which would generate valuable information for the public and the profession was beyond by wildest imagination. And yet, my own institution has been subjected to this kind of restriction through a State Dental Practice Act which, quite surprisingly permits such suppression to occur. It had been my impression that things of this nature occurred only in totalitarian societies such as communistic and fascist political systems. Fortunately, our State Dental Society has recently committed itself to changing this odious statute in the next session of the Legislature. I submit a plea that our profession concentrate on the basic concepts of scientific investigation, objective evaluation, and open forum discussions which are based on documented fact rather than unsupported personal opinion. It seems to me that we should be able to present our arguments in a calm, dispassionate manner which refrains from personal attack on people with whom we might disagree. I believe that most of the people in our profession prefer to go this route but I am afraid that certain vocal minorities on opposite sides of the various issues have fed on emotionalism and dismemberment by personal attack. It has been politically attractive for some of these people to engage in such rhetoric, a regrettable circumstance which threatens to divide the profession from its educational system. If our profession is, in fact, based in science as we claim, it is high time that we return to the method of discussion that stimulates and encourages new ideas and their subsequent evaluation on an objective basis. Once new ap-

proaches are explored and, if they prove to be of benefit to the dental health of the people of a community, region, or the nation, they should be systematically implemented. That is our professional obligation.

One might say that this approach to discussion of matters of interest to the profession of dentistry is a bit idealistic and impractical. Nevertheless, I have seen it work very well on a number of occasions. The most exciting development I have seen in my career in dentistry has occurred through just such a mechanism, and I would like to take a few minutes to describe the program and the process of its development to you.

Approximately four years ago, the North Carolina Dental Society, the Dental Division of the State Department of Human Resources, and the University of North Carolina Schools of Dentistry and Public Health combined their energies to study the dental health situation in North Carolina, and came to some conclusions as to the best way in which the dental health of North Carolinians might be improved over the next decade. Various alternatives were considered such as increasing the number of dentists educated in the state, increasing the number of dental auxiliaries trained in the state and emphasizing more effective utilization of such auxiliaries, and emphasis on prevention of dental disease through a comprehensive public program. After rather careful analysis, it was determined that the least expensive and the most promising opportunity existed in the last option, that of a state-wide

public program in preventive dentistry.

There then followed a comprehensive review of the literature to determine what approaches to prevention were available, their costs, their effectiveness, and their practicality in terms of implementation in the state. Epidemiologists and dental clinicians sat down together and developed various aspects of the total plan, predicting the reductions in the incidence of dental disease which reasonably could be expected over a ten year period in the target population. These estimates were carefully researched and documented. Fortunately, the state had at its disposal, through a study conducted by faculty in the School of Public Health, comprehensive data on the level of dental disease in the North Carolina population with excellent statistics concerning disease rates by geographic region, sex, age, race, and socio-economic background.

The general preventive plan evolved into four components. The first area of emphasis was simply to deliver fluoride therapy by some means to every school child in the state. The least expensive and most effective method was, of course, fluoridation of community water supplies. In North Carolina virtually all of the communities which have water supplies which can be fluoridated are already fluoridated. Nevertheless, incentive grants have been established to help the few remaining communities implement community water fluoridation at minimum expense. The remaining population to be reached by this mechanism was so minimal, that it was felt unnecessary to push for a

mandatory water fluoridation law. There is also a system of grants to upgrade water supplies so that they can be fluoridated. In communities where the water cannot be fluoridated, and where there is no natural fluoridation in the area, school fluoridators are being installed. This approach is regarded as the next most attractive method of fluoride therapy in terms of effectiveness and costs. Seventy such systems have been installed in North Carolina schools already. In areas where community or school water fluoridation is not possible, the students will receive topical fluoride mouth rinses according to the methods indicated in the literature as most effective. The mouth-wash approach to topical application was determined to offer the best cost-benefit situation. Next year 40,000 school children in 800 classrooms will be involved in the topical application program. More students will be added in an incremental manner as resources are made available. Through these mechanisms all children in North Carolina will soon be receiving the benefits of fluoride therapy by one means or another.

Second, in cooperation with the State Department of Public Instruction, an entirely new system of dental health education is being instituted in the public schools. The sections on dental health in existing textbooks have been abandoned as inaccurate and inadequate, and a special teacher's manual on dental health has been developed by the Dental Division of the State Department of Human Resources. It is an excellent publication which will permit each teacher to provide their class with the most current knowledge of

dental tissues, dental disease, and the means by which dental disease can be prevented and controlled. The schools are also cooperating in instruction of students in the proper methods of oral hygiene including flossing techniques. Such instruction will become a regular part of the classroom activity. Naturally this phase will take some time to implement for it is necessary to instruct a large number of people in the proper methods of oral hygiene so that they can, in turn, instruct the students.

The third phase of the preventive dentistry program includes a massive public education program through the news media. Newspapers, radio, and television will be used. Very simply the message that good dental health is possible through fluoridation, good oral hygiene, and regular professional care will be carried to the public on an intensive basis. The main purpose of such a campaign is to provide reinforcement with the parent for students when they come home from their orientation to dental health in the public school system. Techniques similar to those used in the anti-smoking campaign or the heart disease program will be applied. We hope that the messages provided through the media will have some effect on the dental health habits of the adult population as well.

Fourth, a vigorous continuing education program is to be undertaken and maintained to orient the dental profession to an emphasis on the utilization of preventive techniques in their individual practices. The intent is to develop a lot of peer and public pressure to en-

courage such preventive practice by each dentist, thus, providing better service for their patients and extending the number of patients they can accommodate in their practice.

When this four-part plan had been developed, careful study was made of available data in an effort to project what kind of results could be expected over a ten year period. We were very fortunate in having a good data base on the existing disease rate in the population and those data merely needed to be updated. Careful but conservative estimates were made concerning the impact of each section of the program and the total expected result defined. As it turned out, the objectives of the program at the end of ten years are stated as:

1. A 40% reduction in dental caries in children ten years old and under, and;
2. A 25% reduction in dental caries in children twenty years old and under.

In subsequent ten year periods, the 40% reduction in dental caries should work its way up through the entire population and, eventually, there should be an impact on periodontal disease. Data are not sufficient for us to make an estimate on the impact of the program on periodontal disease over an extended period of time. Any benefits in that respect could be regarded as a bonus.

Funding is phased in an incremental basis since it will require some time to implement the entire program. When the program is in full operation, it will cost the state approximately 1.4 million dollars

a year. We are confident that the results will be a real bargain for North Carolinians. Just to be sure, and in part to illustrate our confidence, a study will be conducted at the end of ten years to determine if the disease rates in the target populations have been affected as predicted. The legislature has thus been assured that it will have definitive evaluation of the program.

Once the program was designed and supported with careful documentation, it was submitted to the North Carolina General Assembly for consideration. During the 1973 session, the proposed legislation sailed through with little or no opposition, simply because it was backed with a wealth of scientific evidence and exhaustive documentation. The merits of the program had been debated in the profession on the basis of scientific evidence and it was easy for us to, in turn, present our arguments to lay public. They were obviously impressed and accepted our recommendations.

This program is something of which we are very proud. We believe that it is the first truly comprehensive preventive program to be undertaken in any state in the nation. If its implementation proceeds as smoothly as it has gone to this point, and if our epidemiological projections are accurate, a major step in the promotion of good dental health will have been achieved. In addition, the program can serve as a model for other states. Adaptations would certainly be necessary depending on the conditions in the individual states, but the general approach will have been well documented and carefully tested.

I have taken the time to describe this program to you because I am very excited about it, and because I believe it is an approach which should be considered by dental societies in other states. But more to the point of my presentation today, this program is a product of the kind of discussion which I feel is most productive in the advancement of our profession. There were ideas presented which were researched carefully, conclusions were drawn, documentation was developed, and the most logical plan advanced. Built into the plan are clear and measurable objectives which *will be* measured. So you see, my idealistic approach can and does work. It can be ap-

plied in other areas of concern such as auxiliary utilization, changes in the delivery system, and a variety of other circumstances. I strongly urge that we return to this manner of discussing things, rely on scholarly and informed discourse, refrain from the stifling of new ideas and once again build our discussions on the sound foundation of the scientific method and factual documentation. I am confident that we would all be proud of the results.

Thank you again for inviting me to present the Powell lecture this year. It has been a privilege and I hope that what I have had to say has been worth your time.



A Review of Intravenous Sedation Technics in Dentistry

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I. INTRODUCTION

During the past decade the advent of drugs like diazepam, ketamine, Innovar and many others, have made possible the development of new intravenous sedation technics useful for the ambulatory patient in dentistry. In spite of these advances, we have no ideal drug or drug combination that will be effective and safe for all patients. This is why the dentist must have a thorough knowledge of the pharmacology of these agents in order that he may make the best selection for a particular patient for a specific procedure. Armed with the facts, a clinician can make wise judgments as to the kind of drug and the dose that would produce the desired effect for the type and length of the procedure he is going to perform. All existing intravenous technics have potential hazards, side effects and possible complications, especially in the hands of a neophyte. However, in the hands of a trained clinician any of these technics will be effective and safe. The primary

purpose of this paper is to review the drugs that are in current use with emphasis on their advantages and disadvantages.

II. OBJECTIVES AND INDICATIONS

The pharmacologic objective of intravenous sedation is to produce a cooperative, *conscious* patient who has his protective reflexes intact and is free of both pain and anxiety. It must be emphasized that we are referring to a conscious patient, who is provided with psychological reassurance with a sedative drug and a pain relief with a local anesthetic or analgesic; not to the unconscious patient who is given a general anesthetic. The use of general anesthesia has its place in hospitalized patients, but due to its many disadvantages and dangers it is not recommended for outpatient dentistry except under very special circumstances. This would include an outpatient hospital clinic or the dental office, which has the same facilities as a hospital, as well as a competent anesthetist whose sole

responsibility is to administer the anesthesia and monitor the patient. A dentist working alone in an office can not be both anesthesiologist and dentist when the patient is unconscious.

To accomplish the objectives of intravenous sedation the clinician needs to know five factors: 1) the patient's health status; 2) his degree of cooperation, anxiety or fear; 3) the type and length of the operative procedure; 4) resuscitation and emergency technics and 5) what drugs can and cannot do.

- 1) Information on the patient's health status can be obtained by taking a thorough history and performing a physical examination. If the patient is taking tranquilizers it is important to reduce the sedative dose because these drugs are all central nervous system depressants and their effects will be synergistic. If the patient has pulmonary disease the narcotic analgesics should be used with caution as they may further embarrass the respiration. If the patient is taking a monamine oxidase inhibitor such as pargyline hydrochloride (Eutonyl), the use of meperidine is contraindicated as it may cause central nervous system stimulation, sweating, rigidity, hypertension or hypotension and in some instances even death. The clinician must be aware of what drugs the patient is taking and how these may interact with the drugs he wishes to administer. For an in-depth review of drug interactions the reader is referred to the second edition of *AMA Drug Evaluations* (1973).
- 2) In selecting a sedative drug it is important to properly evaluate the degree of cooperation, anxiety or fear in each patient. Fortunately, many

patients are cooperative and can easily be controlled with a little psychological reassurance and the use of a local anesthetic. Problems arise in the very anxious patient that has marked release of endogenous epinephrine from the adrenal medulla. This patient can be easily recognized by his fast pulse and dilated pupils. The increase in epinephrine will act as a central nervous system stimulant and this patient will be more difficult to sedate, require larger doses of the sedative and present more of a problem to the clinician. The degree of anxiety must be properly evaluated in selecting the type of drug to be used. For instance; the mildly apprehensive patient can be managed with a single drug like diazepam while the extremely apprehensive patient may require deeper sedation with one of the drug combinations.

- 3) One must take into account the type and length of the operative procedure in the selection of a sedative drug. For example: for procedures lasting ten to twenty minutes intermittent methohexital, for those lasting thirty to sixty minutes intravenous diazepam alone or in combination with other drugs and for procedures lasting one to four hours the Shane or Jorgensen technic.
- (4) It is important to remember that intravenous technics are hardly justified unless the safety factor equals or surpasses the standard of care obtained with a local anesthetic. This implies adequate training in the maintenance of an airway in the unconscious patient and a thorough understanding of the pharmacology of the drugs involved. It further requires the ability to deal effectively with anesthesia related complications and emergencies, as well

as knowledge in the use and maintenance of adequate resuscitative drugs and equipment. Sedation and analgesia are stage I of anesthesia and with many of these agents it is very easy to slip into stage II of anesthesia which is the excitation stage. In stage II the patient is unconscious and it is in this stage that many anesthesia accidents occur. (5) Many clinicians and patients alike have the impression that a small dose of a drug is good and a larger dose is better. Nothing could be further from the truth in pharmacology. A little bit more is often worse. Higher doses will often increase the incidence of side effects and enhancement of systemic toxicity. A drug can do so much and no more, most clinical problems arise from pushing a drug. If the effects produced are not adequate, then it may be necessary to use another drug or a drug combination. Administering twice the dose of a barbiturate will not double the sedative effect but it will markedly intensify the respiratory depression and hypotension.

Intravenous sedation is primarily indicated for those highly apprehensive patients who would receive less than adequate care or no care at all, because of their inability to cooperate. Other indications include: the management of patients with mental and/or physical handicaps, the moderately hypertensive patient, the stable cardiac patient, those requiring traumatic surgical procedures, such as the removal of an impacted third molar, the severe gagger, and the preschool child who has extensive dental disease. It is also a practical adjunct in patients requiring extensive restorative treatment,

who desire to complete their dentistry in the fewest possible visits.

III. PHARMACOLOGY

The drugs used in premedication include the sedative-hypnotics, the antianxiety agents, the narcotics, and anticholinergics. These drugs are used alone or in combination. They are all central nervous system depressants and when used in combination their effects are synergistic and the doses must be adjusted accordingly.

A. SEDATIVE-HYPNOTICS

The barbiturates are capable of producing all degrees of depression from sedation to hypnosis to anesthesia to coma and death. The amount of depression elicited is dose dependent. It further depends on the individual drug, the route of administration, the excitability of the central nervous system at the time of administration, the extent of any previous drug tolerance, and the interaction with other drugs being administered. Dripps, Eckenhoff and Vandam (1969) prefer to give the barbiturates intramuscularly as the principal drug for premedication prior to surgery under general anesthesia. This method can also be used for sedation not followed by general anesthesia when the clinician has time to wait for the onset of action. Using this route of administration the barbiturates rarely depress the respiration, circulation, or cause nausea and vomiting. Allergic reactions, such as urticaria, are less common than with the narcotics. Dripps prefers the short acting barbiturates, pentobarbital (Nembutal) or secobarbital (Seconal), in doses of 75-200 mg for adults. These doses inject-

ed intramuscularly have an onset within 30 minutes and a duration of two to three hours.

Sharpless (1971) cautions against the use of intravenous barbiturates unless the situation is an emergency or unless adequate provisions are made for supporting respiration and circulation. He mentions the sudden and very critical fall in blood pressure, which can accompany their administration, especially if given too rapidly. The occurrence of apnea and occasional laryngospasm are always a possibility. Fatal accidents have occurred with the intravenous use of barbiturates by inexperienced people. One of the few absolute contraindications of barbiturates is a personal or familial history of acute intermittent porphyria. Sharpless notes that barbiturate idiosyncrasy is usually seen in the form of a hangover, pain, or excitement. Acquired hypersensitivity may also occur in persons who are prone to allergic reactions. Popular barbiturates used in dentistry include methohexital (Brevital) and pentobarbital (Nembutal).

B. ANTIANXIETY AGENTS (TRANQUILIZERS)

The list of drugs which can be included in this area is most extensive. These drugs are used to control emotional situations that are characterized by anxiety and fear. Dripps, et al., (1969), enumerate the pharmacological effects which constitute the basis of their use for premedication. This includes the sedative action of the drugs per se, the potentiation of narcotics and barbiturates, and their alpha-adrenergic blockade. These drugs also possess anti-

emetic and antihistaminic activity. Dripps further points out that there is a 5-10% evidence of dysphoria or unpleasant restlessness, which may accompany their actions.

Two of the phenothiazines, promethazine (Phenergan) and chlorpromazine (Thorazine), have been used successfully in dentistry. They are used in combination with meperidine (Demerol) to form the "lytic cocktail." Small (1970) found this combination especially effective in children through age 12. As is true in most orally administered drugs it is difficult to titrate the desired dosage level. In some areas this combination is popular but it carries the risk of respiratory depression, hypotension, nausea and long duration of action. This combination is administered orally and will not be discussed in detail.

One of the popular tranquilizers, which has been used primarily in combinations with other drugs, is a diphenylmethane derivative, hydroxyzine hydrochloride (Vistaril). Unfortunately, hydroxyzine is no longer recommended for intravenous use because there have been numerous reports of thrombophlebitis. The fact that hydroxyzine can no longer be used intravenously to produce a rapid onset of action and for ease in titrating the level of sedation is a distinct disadvantage. However, the drug is quickly absorbed after intramuscular administration, because it is water soluble.

One of the more promising anti-anxiety drugs for dentistry is a benzodiazepin compound, diazepam (Valium). This drug has attained

an excellent record by itself. It may also be used effectively in combination with methohexital sodium (Brevital) and with narcotics.

C. NARCOTICS

All of the narcotics are central nervous system depressants. The term narcotic is synonymous with opioid, which refers to any drug having morphinelike pharmacological action. This includes both the naturally occurring drugs, as well as the synthetic agents. The standard narcotic is morphine, which is a phenanthrene derivative of opium. Its action is characterized by analgesia, drowsiness, changes in mood, and mental clouding. Jaffe (1971) has observed that the administration of morphine in the patient without pain may result in dysphoria rather than euphoria. Other undesirable effects include vertigo, nausea, vomiting, and respiratory depression. He mentions that the depressant action of morphine and related narcotics, such as meperidine, is significantly synergized by the phenothiazines, monoamine oxidase inhibitors (e.g. Marplan, Nardil and Parnate) and imipraminelike drugs.

Morphine is a marked respiratory depressant. Jaffe (1971) notes that death from morphine poisoning usually results from respiratory arrest. He states that maximal respiratory depression from morphine is usually seen within seven minutes, but that it may take as long as 30 minutes with intramuscular morphine. Dripps, et al. (1969), state that respiratory depression from intramuscular morphine may last twelve hours or more. For this reason it

is contraindicated for outpatients, being basically a hospital drug. The actual degree and duration of depression is dose related. Jaffe (1971) observed that respiratory minute volume is still considerably below normal for as long as four to five hours after administration of therapeutic doses. Thus, patients with diminished respiratory reserves may react poorly. This includes those with emphysema, asthma, kyphoscoliosis, and cor pulmonale.

Meperidine (Demerol) is a synthetic narcotic that is widely used alone or in combination with other drugs. The synthetic narcotics share essentially the same side effects as those of the naturally occurring compounds. Meperidine depresses blood pressure, cardiac output, and respiration, and stimulates smooth muscles. It is probably only second to morphine in its potency as a narcotic and in its use. As with other narcotics, it is contraindicated in those over sixty-five, as well as patients in poor condition. It should be avoided in asthmatics, because of its bronchiolar constriction. Dripps, et al., (1969) observed that 75 mg of meperidine provides the same alveolar depression of respiration as 10 mg of morphine, but the analgesic potency of 100 mg of meperidine is not equivalent to 10 mg of morphine.

Two other narcotics, which are utilized in current drug combinations, are alphaprodine (Nisentil) and fentanyl citrate (Sublimaze). Alphaprodine is a congener of meperidine, being a phenylpiperidine derivative. Fentanyl has opioidlike actions and is about eighty times as potent as morphine. Its

respiratory depressant action is shorter than meperidine. It is one of the shortest acting narcotics, therefore being useful for short procedures.

D. ANTICHOLINERGIC DRUGS

Atropine and scopolamine are antisialogogues, which act by blocking the parasympathetic postganglionic endings. This action, which blocks the vagus and prevents a bradycardia, is small and of brief duration. The average dosage for these drugs is 0.4 to 0.6 mg intramuscularly, onset is within ten to fifteen minutes with a duration of about ninety minutes. The onset is obviously much more rapid intravenously. The antisecretory, sedative, and amnesic effects of scopolamine are better than atropine. The disadvantage of scopolamine, however, is the restlessness or disorientation it may cause, especially in the very young and in the elderly.

IV. TECHNIQUES UTILIZING ONE PRIMARY DRUG

A. METHOHEXITAL SODIUM (BREVITAL)

The use of intravenous methohexital was first introduced into medicine in 1956 by Gruber, et al. It became a very popular agent in Great Britain during the 1960's. Its use in dentistry developed into two techniques: 1) Foreman (1970) describes this technic as intermittent methohexital sodium anesthesia. This is further described by Mann, et al., (1971). Mann and his co-workers first administered 0.6 mg atropine sulfate, followed by a test dose of 20 mg of 10% methohexital. If no adverse reaction occurs, 10% methohexital is injected to a total of 0.8 to 1.3 mg/kg. The

average induction dose is between 60 and 100 mgs. No local anesthesia is used with this technic. Additional doses of approximately half the induction dose are given when the patient's response to stimuli indicates the need. Foreman suggests that the total dosage be limited to 200 mgs with total operating time restricted to 20 minutes. Mann, et al., (1971) and Hatt, et al., (1971) found this technic to be inferior to the use of a local anesthetic as the sole agent. They were able to complete a greater number of restorations with the methohexital technic, but treatment had to be abandoned in 13% of the cases due to poor patient response. There was also a comparatively high incidence of side effects and after effects. These included respiratory obstruction and hypoxia, inadequate pharyngeal and laryngeal reflexes, peripheral vasodilation and inadequate access (Hatt, et al., 1971; Wise 1969). They could not justify its use in conservative dentistry. 2) This technic involving methohexital is referred to by Foreman (1967, 1970) as the intravenous methohexital sodium sedation. Increments of 10-20 mg of methohexital are given until the patient is deeply sedated but still able to respond to a question. At this point the patient is totally amnesic and operative procedures are carefully initiated. If the patient responds to painful stimulus, local anesthesia and/or verbal reassurance usually results in a cooperative patient. Sedation and amnesia are maintained by addition of small increments as needed.

The advantages of methohexital include short duration of action and a fast recovery time. The drug

is stable in solution and provides good amnesia. There is also a relative absence of complications. A current survey of 445,386 administrations showed a 0.1% incidence of nausea or vomiting, a 0.2% incidence of recovery beyond one hour, and a 0.1% incidence of laryngeal spasm (News Sheet 1968). Temporary respiratory disturbances may be seen occasionally during induction. Hiccups are sometimes observed and are often associated with a rapid induction. It is important to keep the patient supine. Some individuals do not respond to this technic and remain highly resistant and restless. For these patients barbiturates, such as methohexital or pentobarbital, can be combined with other drugs, which provide the additional psychic relaxation.

B. DIAZEPAM (VALIUM)

Diazepam (Valium) was synthesized by Sternback and Reeder in 1961 (Brown, et al., 1968). It belongs chemically to the benzodiazepine group with a structure resembling chlordiazepoxide (Librium). It is active both orally and parenterally. Diazepam is very insoluble and should never be mixed with other drugs in the same syringe or diluted in any fashion with intravenous solutions. The drug will crystallize and cause problems. Diazepam is used as a tranquilizer for premedication, for the induction of anesthesia, for cardioversion, for the treatment of tetanus and muscular spasm, and the scope for its use is constantly expanding (Kay 1970). The drug appears to act on the amygdala, hippocampus, blocks the reticular activating system, reduces psychomotor activity and suppresses aggressive behavior (Tornetta 1965).

Diazepam has been used in dentistry since 1964. It was first used orally (Lipkin 1968, Peabody 1965) and was later introduced for intravenous sedation in dentistry by Albert A. Davidau (1965). Since then it has enjoyed wide use and is rapidly becoming the drug of choice for intravenous sedation in outpatient dentistry. Its feasibility has been established for sedation in minor oral surgery (Brown, et al., 1968, Khosla and Boren 1969, O'Neil, et al., 1970, Poswillo 1967, Shane 1971) and conservative dentistry, (Baird and Curson 1970, Rattray 1968) and as an adjunct in the management of very anxious children and the mentally retarded (Healy and Edmondson 1970, Healy and Hamilton 1971, Peabody 1965). Diazepam appears to be most effective in patients who are anxious and apprehensive but of cooperative temperament (Brown, et al., 1968; O'Neil, et al., 1970). One of the most outstanding features of this drug is the retrograde amnesia it provides (Healy and Hamilton, 1971, Khosla and Boren 1969, O'Neil, et al., 1970, Poswillo 1967). It is usually administered in combination with a local anesthetic. Atropine is often given, if an antisialogogue is required.

For dental procedures, diazepam (5 to 20 mg IV) usually results in emotional relaxation with a loss of tension and fear in the patient. Foreman (1970) recommends that the drug not be given at a rate faster than 2 mg/30 seconds. The onset of action is 1-2 minutes and duration about 30-40 minutes. For longer procedures an additional small dose may be desirable. The following signs of adequate dosage appear to be consistent in a num-

ber of studies (Litchfield and Gerard 1971, Rattray 1968, Schofield 1970). The patient becomes relaxed with a slight slurring of speech and a feeling of well being. There is a ptosis or partial closure of the eye lids and the eyes appear still with a hint of glazing. There is also an inability of the eyes to focus.

The enthusiasm for diazepam is not as consistent in the studies with children as it is with adults. Brown, et al., (1968) reported disappointing results in children. Litchfield and Gerard (1971) did a study involving 1,557 cases of various ages. They injected 2.5 to 5.0 mg per minute until the desired effect was attained. The average dose was between 15 and 20 mg. The results were classified as poor, moderate, and good. Poor refers to those patients who were unmanageable. Moderate and good referred to cooperative patients. Eighty four percent of children under the age of 11 reached the good and moderate level. The percentage rose to 89% in those 12 years or over, but they found the best results in patients 20 or more. They further noted the advantage of a 5 mg diazepam tablet taken the night before the appointment, and another 5 mg taken early the next day and a subsequent 5 mg taken one hour pre-operatively.

Healy and Hamilton (1971), (Healy and Edmondson 1970) did studies in both normal and mentally retarded children. In normal but highly anxious children they used 1 mg per year of age for those under 10, and 15 mg intravenously for those over 10 years. They reported three poor results out of nineteen children. Included in the sixteen children that were coop-

erative were two children who cried quietly. They observed that all patients were quiet post-operatively and willing to return. In the retarded group they used the same dosage for those under 10. In the 10-15 year olds they administered 15 mg to the boys and 10 mg to the girls and in those over 15 they gave 25 mg and 20 mg respectively. Only 2 out of 44 in this group proved to be difficult to manage. Their successes included four athetoid patients, who previously required general anesthesia to reduce their continuous movements.

The side effects and after effects from diazepam appear to be minimal. The unwanted effects include: hypotension, depression, dizziness, postural hypotension and latent fatigue. Baird and Flowerdew (1970) noted that these effects seemed to appear primarily in doses over 30 mgs. Dalen, et al., (1969) did a study of 5-10 mg doses of diazepam for cardiac catheterization. They observed minimal decrease in blood pressure and ventilation. Brown, et al., (1968) did a study with 108 patients and did not see problems of decreased blood pressure or ventilation. They felt these effects were unlikely if the patient was kept supine, atropine was given, the drug was titrated slowly, and if diazepam was avoided in patients with cardiovascular disease. The manufacturers of diazepam also recommended the supine position for at least an hour after administration. Foreman, Neels and Willets (1969) noted that marked potentiation of central depressants, such as, with the barbiturates, has been seen with diazepam, another disadvantage is a partial loss of laryngeal protective

reflex for 5 to 10 minutes after intravenous diazepam. It may be ineffective in preventing the aspiration of oral contents. A reduction of the gag reflex was also noted by Foreman (1970), Litchfield and Gerard (1971). This factor can be used to the patient's advantage for the control of severe gag reflexes in patients with this problem. Another disadvantage is occasional phlebitis and irritation at the injection site. Langdon, Harlan and Bailey (1973) in a study of 1,500 administrations of intravenous diazepam obtained a 3.5% incidence of thrombophlebitis. To decrease the incidence and severity of the thrombophlebitis they recommend that small veins be avoided and that a saline flush should be used after the administration of diazepam.

V. DRUG COMBINATIONS

A. DIAZEPAM AND METHOHEXITAL SODIUM

Foreman, Neels and Willets (1969) developed a technic utilizing both of these agents together. Their observations were based on the treatment of 167 patients in a general practice. In 27 patients they gave diazepam and atropine prior to the administration of a local anesthetic. In a subsequent trial with 140 patients, they supplemented the sedation provided by diazepam with methohexital. This provided better amnesia and deepened the sedation. This combination lessened the amount of barbiturate required. Patients were very alert at the conclusion of treatment. It is particularly helpful for procedures requiring 30 to 90 minutes of operating time.

Foreman, Neels and Willets (1969) administer the diazepam

until a stage of light relaxation and sedation is achieved. Methohexital is then injected in 5-10 mg increments. Often the first dose of methohexital is sufficient to produce a marked sedation within one minute. If this is ineffective, further increments are given. These periods of deepened sedation are used to cover unpleasant procedures, such as the injection of local anesthetic for extractions. Patients who become restless after the administration of methohexital are treated solely with diazepam. This agitation in some patients may be due to barbiturate idiosyncrasy. Foreman notes that 5 to 10 mg of diazepam and 50 to 100 mg of methohexital are often sufficient for procedures lasting longer than one hour.

B. SODIUM PENTOBARBITAL AND MEPERIDINE HYDROCHLORIDE

The combination of sodium pentobarbital, meperidine and scopolamine is known as the Jorgensen technic (Jorgensen 1966, Jorgensen and Hayden 1967). It has been used by Neils Jorgensen since 1946. Pentobarbital (Nembutal) is used for sedation. Meperidine (Demerol) is used for sedation, euphoria and analgesia, and scopolamine hydrobromide provides antisialosis and retrograde amnesia. This combination usually results in a cooperative but relaxed patient who will calmly accept three hours or more of extensive restorative and surgical procedures without apparent discomfort. The patient remains conscious throughout and is able to assist the operator, if necessary.

Pentobarbital is injected slowly, until the first cortical symptoms of depression are noticed. This is

characterized by a slight drowsiness, dizziness, blurring of vision, or psychological relaxation. Jorgensen calls this stage the baseline level. The amount needed to reach this level has ranged from 10 to 300 mg of pentobarbital. After the baseline is reached, an additional 10% to 15% of pentobarbital is given. Blood is aspirated into the syringe to clear the needle and/or IV tubing of any residual pentobarbital before a second syringe containing 25 mg of meperidine and 0.4 mg of scopolamine is attached. This is necessary, since pentobarbital will form a precipitate with meperidine. If the patient requires 100 mg of pentobarbital, the total dosage is injected. If only 50 mg of pentobarbital are needed, then only 12.5 mg of meperidine is injected.

Everett and Allen (1971) found no significant changes in arterial blood pressure, cardiac output, central venous pressure, total peripheral resistance, pO_2 or pCO_2 . The cardiac rate showed a progressive decrease with the exception of a transient increase immediately after injection of a local anesthetic. Some nausea may occur and is dose related to meperidine. The technic must be used with extreme caution in patients on antihypertensive drugs, as well as patients taking anti-depressant drugs, especially the monoamine oxidase inhibitors.

C. HYDROXYZINE HYDROCHLORIDE, ALPHAPRODINE HYDROCHLORIDE, AND METHOHEXITAL SODIUM

This combination with atropine was designed by Sylvan Shane (1966, 1971), (Shane and Vandenberg 1971) for procedures of one to four hours duration. It may

be used for both restorative and surgical procedures. Good blocks with local anesthetics as well as intensive suggestion are integral parts of this technic. Alphaprodine (Nisentil), atropine, and hydroxyzine (Vistaril) are combined in a single syringe and given slowly intravenously. (Since hydroxyzine is no longer recommended for intravenous use, Shane's technic has to be modified using hydroxyzine intramuscularly). The dosages in children from two to six are 6 mg of alphaprodine and 0.3 mg of atropine. Between ages 7 and 17, 1 mg of alphaprodine is given per year of age and 0.6 mg of atropine. The hydroxyzine dose for children two to six is 25 mg. It is between 25 and 50 mg for ages 7 to 17 and 50 mg in adults. Hydroxyzine is both a tranquilizer and anti-emetic. The required methohexital, which potentiates the sedative action of alphaprodine, is given in 10 to 30 mg increments.

A most important aspect of this technic is the intensive predrug suggestive phase. The patient is told that he will be asleep before any drugs are administered. He is told when he awakens he will feel as though he were asleep only for a few seconds, yet, his operation will be completed. He will know this because he will be numb, and he will hear the sound of the high speed handpiece polishing his restorations. Incremental methohexital is used to supplement the amnesia and further potentiate the patient's apathy and sedation.

Miller (1971) did a study using the Shane technic in 100 patients from 6 to 45 years of age. He reported the method to be 100% effective in most age groups with

the exception of the 31 to 45 year level. No means of intensive suggestion was completely effective in preventing memory traces in this group. Yet, they still remained very enthusiastic the following day because of the lack of discomfort. Shane (1966) did a study based on 500 patients from 2 to 68 years. He found that the technic failed only in uncooperative and combative children under six, who would not listen to the intensive suggestion. In these children a light plane of anesthesia was required for cooperation.

D. SODIUM SECOBARBITAL, MEPERIDINE HYDROCHLORIDE AND METHO- HEXITAL SODIUM

This technic was developed by Joel Berns (1963). He claims that this method allows for a more accurate dosage with a faster recovery time. Basal narcosis is provided with the administration of up to 50 mg of secobarbital (Seconal), which is followed by 25 to 50 mg of meperidine. Incremental methohexital is added to temporarily deepen the sedation for unpleasant procedures.

VI. NEUROLEPTANALGESIA AND DISSOCIATIVE ANESTHESIA

Neuroleptanalgesia and dissociative anesthesia are new terms which refer to drugs which cause a general quiescence and a state of psychic indifference to environmental stimuli but do not produce sleep or the classic anesthetic syndrome. A frequently used combination of neuroleptic compounds is droperidol (Inapsine) with a potent narcotic analgesic fentanyl (Sublimaze). The combination of these two drugs is marketed under the name of Innovar. Droperidol is a potent anti-

emetic as well as being a mild alpha adrenergic blocking agent. Its duration of action is between four to six hours, with some effects persisting up to 18 hours (Jones, et al., 1969). The narcotic, fentanyl, has a rapid onset and a short duration of action about 30 minutes. Droperidol's long duration of action is a distinct disadvantage for its use in outpatient dentistry. Bennett and Monheim (1972) reported side effects were seen in 29% of the patients who participated in their study with Innovar. Franceschi (1971) and Kempf (1971) in separate studies, however, have reported favorably on their experience with Innovar. In another study using Innovar for oral surgery, Nyberg, et al., (1970) concluded that it should probably be used in the hospital only due to its prolonged postoperative sedation with respiratory depression and muscle rigidity.

Another recent agent which appears to have some promise in children is the dissociative agent, ketamine hydrochloride. Its use in oral surgery and conservative dentistry has been reported (Spoerel 1970; Young and Epker 1971). It has several advantages over other anesthetic agents for outpatients. It is easily administered, has a fast onset with a minimal respiratory depression and with minimal loss of laryngeal-pharyngeal protective reflexes. A disadvantage is a 7.6% incidence of unpleasant emergence phenomena that is manifested by irrational behavior and undesirable psychomotor activity. These phenomena are most often observed in adolescents and adults but rarely in children.

Young and Epker (1971) found that a minimum of 2.5 mg/lb of

body weight was needed for effective dental anesthesia, when administered IM. Surgical levels were obtained in 3 to 4 minutes, but recovery times ranged from 45 minutes to more than one hour. They found that the minimum intravenous dosage was 0.5 mg/lb of body weight, but found that 1 mg/lb provided more optimal conditions. No significant respiratory or cardiovascular problems were encountered, and all patients maintained a patent airway without assistance. Spoerel (1970) also reported similar observations in his studies with 310 children, who had extractions under ketamine, with 5 children also having conservative dentistry performed. However, he reported a 41% incidence of postoperative vomiting. Both of these studies were done in hospital situations with trained anesthesiologists providing the anesthesia.

VII. SUMMARY

The current indications, technics, and drugs used in intravenous se-

dation have been described. Unfortunately, the ideal drug has not been developed. All of the various agents have side effects and disadvantages. Even under the best circumstances with a trained anesthesiologist in a hospital, complications can and do occur. It is most important to be fully aware of the pharmacology of the various drugs and to be able to diagnose effectively and treat their complications. It is also most important to be fully aware of the medical status of the patient prior to treatment. This information can usually be obtained by taking a good history and conferring with the patient's physician, whenever there are any questions. It is essential that the clinician using these technics be properly trained clinically as well as academically. This implies the ability to maintain a good airway in the unconscious patient and the ability to handle competently and efficiently any conceivable emergency that may arise.

DRUG SUMMARY TABLE*

I. SEDATIVES-HYPNOTICS AND ANTIANXIETY AGENTS

DRUG	DOSE	REMARKS
<i>Barbiturates</i>		
pentobarbital Na (Nembutal)	P.O. 100 mg onset 45 min, duration 3-4 hrs, IM 75-200 mg, onset 30 min, duration 2-3 hrs. IV 50-500 mg max.	excellent antianxiety, safe, little or no effect on vital functions, not good in children, elderly, porphyria, <i>no analgesia</i> , hangover
secobarbital Na (Seconal)	same as pento- barbital Na	
methohexital (Brevital)	initial sedative dose 10-100 mg IV, maintenance 10-20 mg increments on- set 30 sec. duration 5-7 min.	induction simple, rapid & pleasant, recovery rapid, good for ambula- tory patients, excellent amnesia & sedation, not used in porphyria, pulmonary insufficiency, liver dis- ease, acidosis, cardiac decompen- sation, anemia, hypothyroidism, re- sponse variable, only good for short procedures up to 20 min.

*See text for references.

*Nonbarbiturate
sedatives*chloral hydrate
(Noctec)P.O. 250-500 mg
onset 30 min
duration 3-5 hrs.

one of best, oldest sedatives, no hangover, no effect on vital functions, few side effects, drug of choice in children & elderly, some gastric irritation, not used in marked hepatic or renal disease or with coumarins

*Antianxiety agents*chlorpromazine
(Thorazine)
phenothiazineP.O. 25-50 mg
2-3 hrs before
operation, IM
12-25 mg, 1-2 hrs
prior to procedure

sedative, antiemetic, potentiates narcotics, not good for preoperative sedation, danger of hypotension as adrenergic blockade, too many side effects, duration too long

promethazine .HCl
(Phenergan)
phenothiazineP.O. 25 mg, onset 1
hr, duration 3-4 hrs

very useful for preoperative sedation, antihistaminic antiemetic properties, may intensify sensitivity to pain, dysphoria and unpleasant restlessness in 5-10% of patients

hydroxyzine .HCl
(Vistaril, Atarax)
butyrophenone
derivativeIM 25-100 mg, no
longer recommended
for IV use.

good antianxiety, sedative, antihistaminic, antiemetic, antispasmodic, no deleterious effect on vital organs, incidence of side effects low

diazepam
(Valium)
benzodiazepin
compoundIV 5-20 mg, rate
5 mg/min onset 1
min, duration 30-
45 min.

anxiolytic, sedative, amnesic & muscle relaxant, good sedative for ambulatory patients, rapid induction & recovery, no significant effects on vital functions, laryngospasm and increased cough reflex may occur, painful injection, occasional phlebitis and irritation at injection site, useful for procedures up to 1 hr.

II. ANALGESICS*Narcotic analgesics*

morphine

5-10 mg IM or sub.
q., duration 4-5
hrs.

good analgesia, drowsiness, changes in mood, mental clouding, nausea and vomiting, respiratory depression, may last up to 12 hrs., dangerous in pulmonary disease, not justified for short procedures because long duration of action. Mainly a hospital drug.

meperidine
(Demerol,
Pethidine)50-100 mg sub. q.,
IM or PO, duration
2-4 hrs.

good analgesia, sedation, some euphoria and respiratory depression, better for short procedures than morphine, some nausea and hypotension, not used in asthma

alphaprodine
(Nisentil)40-60 mg sub. q. or
P.O. duration
1-2 hrs

potent analgesic, more rapid onset and shorter duration than morphine or meperidine, some respiratory depression, effective by any route of administration, good in ambulatory patients

III. ANTISILAGOGUES (anticholinergic)

atropine	0.4-0.6 mg sub. q. 40-60 min. prior to induction, if IV 10 min prior
scopolamine	same as atropine

antisilagogue, blocks parasympathetic postganglionic system, thus prevents bradycardia by blocking the vagus (better than scopolamine in this respect)

better than atropine for drying secretions, produces more sedation and amnesia than atropine, some patients especially the elderly on recovery become restless and agitated but this effect is not as common as widely believed

IV. DISSOCIATIVE DRUGS

Ketamine (Ketalar)	0.5-1 mg/lb IV onset 1-2 min. duration 5-10 min 2.5 mg/lb IM onset 3-4 min duration 12-25 min
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narcoleptic or dissociative drug, profound analgesia and amnesia, no muscle relaxation, no depression of respiration or circulation, during emergence vivid dreams with confusion and irrational behavior may occur more so in adults than children, recommended for uncooperative children, main problem long recovery 1-2 hrs.

Innovar	
1. droperidol (Inapsine)	2.5 mg
2. fentanyl (Sublimaze)	0.05 mg given IV over 5-10 min duration less than meperidine, usually about 30 min.

droperidol is a major tranquilizer, more potent and less toxic than thorazine with less sedation, also antimetic *fentanyl* similar to opioids, 80x more potent than morphine, little emetic or hypotensive properties, narcotic analgesic

Innovar dissociative, analgesic, sedative, antiemetic, mild to moderate hypotension, respiratory depression almost invariably requiring assisted ventilation, "lead pipe syndrome"

V. DRUG COMBINATIONS

Foreman

Diazepam	5-20 mg IV,
Methohexital	50-100 mg in 5-10 mg in- crements IV

methohexital superimposed on diazepam to cover unpleasant procedures, these periods of deepened sedation last up to 5 min, enables reduction of barbiturate dose, amnesia enhanced, useful in patients previously restless with methohexital alone, extremely useful combination in procedures lasting 1 hr or more

Shane

hydroxyzine	25-50 mg IM
atropine	0.3-0.6 mg IV
alphaprodine	6-30 mg IV
methohexital	30-60 mg IV incremental doses of 10-20 mg

good for procedures lasting 30 min up to 4 hrs, recommended for total dentistry in one sitting, patient conscious, analgesia, amnesia and sedation, useful in cooperative patients of all ages

hydroxyzine	100 mg PO or IM 30-60 min preop.	sedative, analgesic, useful pre-operative sedation with few side effects, good in adult problem patients or in poor risk patients
meperidine	25-50 mg in saline IV	
<i>Mepergan</i>		
meperidine	25 mg	sedative, analgesic, amnesic, anti-emetic, and antihistaminic, agents potentiate each other so dose of each reduced, meperidine controls pain obviates the occurrence of athetoid reactions often seen with promethazine alone, useful for adults
promethazine	25 mg 1-2 ml IM or IV	
<i>Berns' "Twilight sedation"</i>		
secobarbital Na	50 mg IV	claims good ability to "tailor fit" sedation to length of procedure by controlling different doses so that recovery is shorter than that required by other techniques, all these drugs are hypotensive and respiratory depressants and may synergize these effects
meperidine	25-50 mg	
methohexital	20 mg increments IV	
<i>Jorgensen</i>		
pentobarbital Na		pentobarbital is injected 10 mg/30 sec. until initial cortical symptoms observed, then add 10-15% of original dose, meperidine incompatible with barbiturate so must use different syringes, patient is sedated, analgesic and amnesic, long induction (10 min or more) and long recovery, useful in procedures of 3 or more hours
meperidine	25 mg	
scopolamine	0.4 mg	
<i>Lytic cocktail</i> contains following/ml		
meperidine	25 mg	dose is about 1 ml of lytic cocktail per 30 lbs., tranquilizer analgesic, sedative, antiemetic and antihistaminic, effective for children through age 12 largely replacing the barbiturates, danger of respiratory depression and frequent hypotension
promethazine	6.25 mg	
chlorpromazine	6.25 mg	

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**Potentialiation of Local Anesthetic Toxicity I:
Effects of Various Preadnesthetic
and Therapeutic Agents
on the CNS Toxicity
of Lidocaine and Prilocaine**

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SUMMARY

The CNS toxicity of the local anesthetic lidocaine was greatly potentiated by promethazine and morphine and to a lesser extent by meperidine, reserpine, diazepam and pentozocine. The combination of promethazine and meperidine had a very marked potentiating effect. Prilocaine was most potentiated by meperidine pretreatment and to a lesser degree by morphine, promethazine and pentazocine. Again the combination of promethazine and meperidine were more potentiating than either agent alone.

INTRODUCTION

The use of auxiliary medication in dental patients is receiving

widespread publicity in the literature. This has led to a marked increase in the use of the so-called preanesthetic agents by the general practitioner. Copen (1947) was the first to investigate the feasibility of the use of meperidine hydrochloride with local anesthesia. He also reported on the use of atropine as a co-medication in local anesthesia to reduce salivary secretions (Copen 1950). Catania and Kringstein (1962) recommended the use of meperidine-promethazine cocktail as premedication in ambulatory patients who exhibited apprehension and anxiety. Alburn (1961) has advocated the use of meperidine and promethazine with a local anesthetic agent in dentistry of retarded, emotionally disturbed or disabled children.

It has been recognized that the use of local anesthetics alone is not unattended by toxic and possible fatal pharmacologic responses of the recipients. Dobbs (1966) and Dobbs and Ross (1968) investigated the convulsive properties of local anesthetic drugs. Crampton and Oriscello (1968) have observed petit mal and grand mal convulsions following the administration of lidocaine hydrochloride. Foldes et al (1960) have compared the toxicity of local anesthetics in man. It has been reported (Tarsitano 1965) that a combination of promethazine, meperidine and mepivacaine proved fatal when administered to a four year old child.

The purpose of this paper is to describe the effects that various sedatives, tranquilizers and analgesics, commonly taken by the patient or administered to the patient before local anesthesia, have on potentiating central nervous system (CNS) toxicity of lidocaine and prilocaine in rats.

MATERIALS AND METHODS

Each drug used in the experiment was injected intramuscularly (IM) into groups of ten white, male Wistar rats weighing approximately 100 g. When injected alone at the highest dose reported in this article no drug produced any sign of central nervous system stimulation as defined by the presence of tremors, or convulsions and no deaths occurred among the animals in 24 hours. All animals used in this experiment were observed continuously for the first four hours, at six and eight hours and again at 24 hours.

All non-anesthetic agents were injected IM thirty minutes prior to the injection of the local anesthetic with the exception of reserpine which was injected 120 minutes prior to the local anesthetic. The local anesthetics were injected without vasoconstrictor IM, on the opposite side of the animal from the non-anesthetic agent. Groups of 4 rats were used for each dosage

TABLE I
Potentiation of Toxicity of Lidocaine by Various Therapeutic Agents

Drug	Dose (mg/kg)	ED ₅₀ * (mg/kg) for Tremors	Lidocaine to Produce Death
Saline	1 ml	>200	>200
Reserpine	2.5	80±4*	100±4
Chlordiazepoxide	50	>200	>200
Diazepam	10	80±4	100±4
Promethazine	25	40±2	60±4
Meperidine	50	80±4	120±6
Morphine	10	40±2	80±4
Nalorphine	5	160±	>200
Pentazocine	30	80±4	140±6
Meperidine	25	160±6	200±8
Promethazine	12.5	160±6	200±8
Meperidine	25		
+		40±2	100±4
Promethazine	12.5		
Chlorpromazine	25	40±2	120±6
Hydroxyzine	50	120±6	200±8

*Standard error of the mean for 95% confidence limits.

level of local anesthetic. The appearance of tremors, convulsions or death were recorded for each combination of local anesthetic and pre-anesthetic drug. The ED_{50} for the local anesthetic to produce tremors, convulsions or death was determined for each non-anesthetic drug pretreatment. The ED_{50} and standard error of the mean for 95% confidence limits was calculated by the method of Litchfield and Wilcoxon (1949).

RESULTS

The results of the lidocaine experiments are given in Table I while the results of the prilocaine experiments are given in Table II. The doses of the pretreatment agents are given next to the name. The ED_{50} and standard error of lidocaine to produce tremors is found in column three in Table I and the ED_{50} and standard error to produce death is found in col-

umn four. No convulsions were observed at any dose of lidocaine used in this experiment. Promethazine at a dose of 25 mg/kg caused the greatest potentiation of lidocaine toxicity. At a dose of 12.5 mg/kg of promethazine and 25 mg/kg of meperidine, the combination of these two agents was approximately four times as potent in potentiating lidocaine toxicity as either agent alone. With prilocaine (table II) convulsions as well as tremors were a prominent part of the CNS toxicity pattern.

When prilocaine was used alone more than 400 mg/kg was required to cause any observable CNS toxicity. The pretreatment of animals with 50 mg/kg meperidine lowered the ED_{50} of prilocaine required to produce tremors to 10 mg/kg and to produce convulsions and death to 40 mg/kg. Again the combination of promethazine and meperidine

TABLE II
Potentiation of Toxicity of Prilocaine by Various Therapeutic Agents

Drug	Dose (mg/kg)	ED_{50} * (mg/kg) for Prilocaine to Produce		
		Tremors	Convulsions	Death
Saline	1 ml	>400	>400	>400
Reserpine	2.5	$320 \pm 12^*$	360 ± 12	400 ± 12
Chlordiazepoxide	50	>400	>400	>400
Diazepam	10	>400	>400	>400
Promethazine	25	240 ± 8	320 ± 10	320 ± 10
Meperidine	50	10 ± 2	40 ± 4	40 ± 4
Morphine	10	200 ± 10	280 ± 12	>400
Nalorphine	5	320 ± 10	320 ± 12	>400
Pentazocine	30	200 ± 10	240 ± 12	280 ± 12
Meperidine	25	240 ± 10	280 ± 10	360 ± 12
Promethazine	12.5	>400	>400	>400
Meperidine	25			
+		120 ± 6	280 ± 10	280 ± 12
Promethazine	12.5			
Chlorpromazine	25	80 ± 4	120 ± 4	280 ± 8
Hydroxyzine	50	160 ± 6	160 ± 6	400 ± 12

*Standard error of the mean for 95% confidence limits.

dine at 12.5 and 25 mg/kg respectively was more than twice as potentiating of prilocaine toxicity as either agent used alone.

DISCUSSION

It appears from the results that we have obtained in rats, that the two agents promethazine and meperidine, which are used most frequently alone or in combination as preanesthetic medication to allay anxiety and apprehension and to sedate patients about to undergo some type of dental or surgical treatment involving a local anesthetic, are agents which greatly po-

tentiate the CNS stimulatory properties of local anesthetics. Other tranquilizer agents such as chlor-diazepoxide, diazepam and hydro-xyzine do not appear to have as great an effect. Chlorpromazine does significantly potentiate the toxicity of these local anesthetics. Perhaps we should look for anti-anxiety and anti-apprehensive agents which will not potentiate local anesthetic toxicity. Aside from these considerations one must be aware of possible drug interactions between any medication the patient may be taking and the local anesthetic.

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Melanin: Visualization and Quantification

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Melanin: Visualization and Quantification

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SUMMARY

A method of visualization and quantification of epithelial melanin is described whereby unstained slides are examined in a combination of ultraviolet and white light.

MELANIN: VISUALIZATION AND QUANTIFICATION

During a study of ultraviolet fluorescent and absorption phenomenon associated with the healing of skin wounds, it became apparent following studies in this laboratory that the standard histological and histochemical methods for melanin examination did not reveal sufficient data as they were too unreliable to quantitate. In order to quantify the amounts of epithelial melanin, it was necessary to devise additional techniques. It was, therefore, decided to combine the dark field light scattering properties of melanin which absorbs light through the ultraviolet and visible spectra, and the autofluorescent properties of other epidermal and dermal structures to visualize and photometrically quantify melanin concentration.

Portions of skin were fixed in neutral formal calcium at 4° C.,

paraffin embedded, sectioned at a thickness of 8 micrometers, processed in the usual manner and mounted *unstained*, using a non fluorescent mounting medium, e.g., D.P.X. The specimens were examined on a Reichert Zetopan microscope with microspectrophotometer, using dark field fluorescence, with an excitation wave length of approximately 365 nm. and a barrier filter cutting off all light below 400 nm. When the tissue was exposed to this excitation wave length, the epithelial structures had a fluorescence peak of approximately 475 nm.; except for melanin, which absorbed ultraviolet light. Therefore, by changing the light source to introduce 10% white light from a 6 V. tungsten lamp an unusual picture was obtained (Fig. 1). This method of mixed illumination gave a distinctive appearance of the fluorescence of the epithelial structures as a blue background for the brightly illuminated melanin granules.

To quantify the amount, or density, of melanin the measuring spot in the photometer was located in such a position as to allow the basement membrane to bisect the

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spot. This gave uniformity of measurement sample area. The output was then measured at a wave length of 550 nm., which was the peak wave length emission of the tungsten lamp, and, therefore, also that of the melanin granules.

It is, of course, realized that even though not visible through the bright melanin granules, the 475 nm. fluorescent peak is still present in the surrounding tissue. It was decided, however, that this fluorescence effect could be discounted in quantification as the intensity of emitted light was so low that no photometric response, except that of the white light from the melanin, was detectable when

the specimen was scanned from 400–700 nm. An amplification of 8 times was necessary before any photometric response could be detected from the fluorescent background.

It is felt that this simple consistent method of melanin determination is of potential value as it requires no staining of the specimen. It does, however, require microscopical capability of mixed white and ultraviolet illumination and dark field illumination. The use of this technique is by no means limited to quantitative microscopy, but could be used in routine laboratory procedures whenever it is desired to visualize melanin.

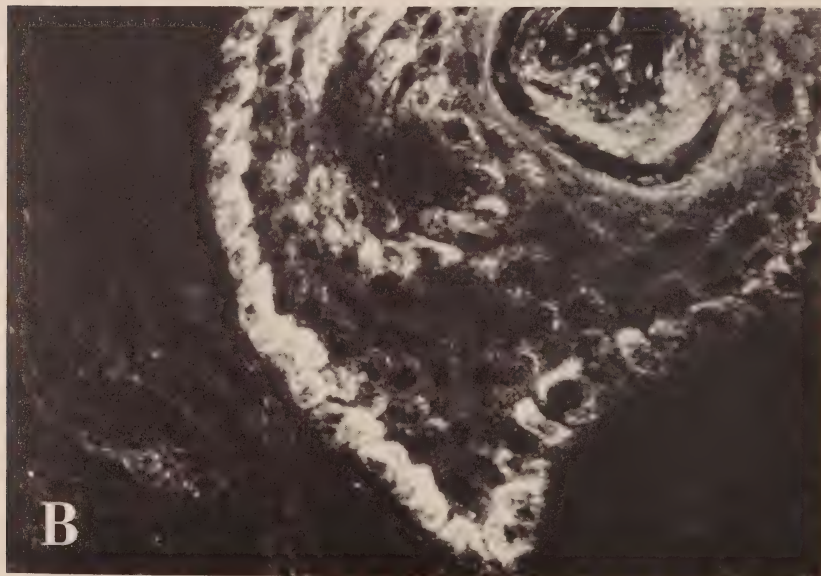
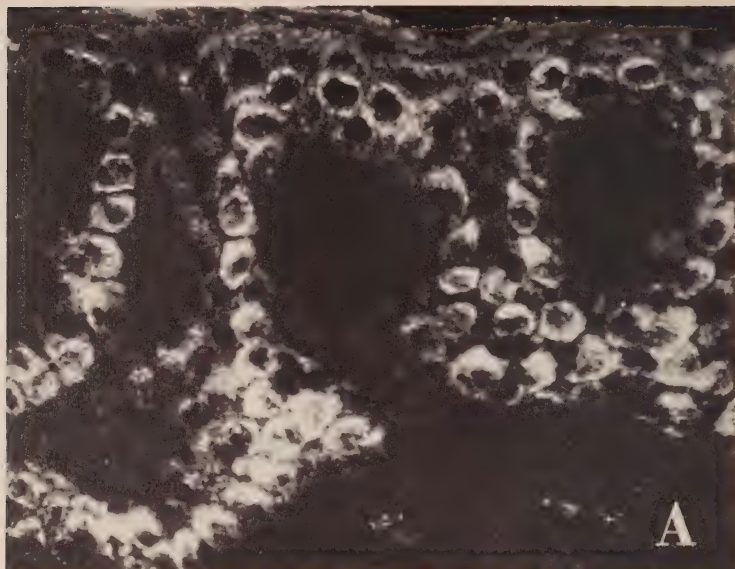


Fig. 1: A & B. Unstained cross-sections of Caucasoid human abdominal skin illuminated to reveal melanin.

Quality Production of Instructional Media In Dental Education: An Instructional Model

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Quality Production of Instructional Media In Dental Education: An Instructional Model

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In recent years there has been an increasing awareness of the contribution which instructional media can make to dental education. Likewise there is an increasing awareness of the contributions which self-instructional media have to offer. With the increasing emphasis being devoted to self-instruction and more and more schools producing such media, there is being voiced an increasing concern about the format for designing and developing quality self-instructional materials for dental education.

In order to design and develop quality instructional materials, a "systems" approach is recommended. That is, a systematic series of steps designed to accomplish a desired outcome. This systematic approach includes five steps (Figure 1) each of which represents certain basic decisions with regard to the design and development of the instructional materials.

STEP 1: TASK ANALYSIS

The task analysis begins with an audience analysis. This enables the instructional designer to assess the entry level of the students and to determine what information and

skills they *know*. From this point, the instructional task is analyzed in order to identify the information and skills the students *need to know*. This needed information provides the basis for the preparation of the instructional materials and is phrased in the form of behavioral objectives.

The objectives should include a statement regarding the student's performance. If it is appropriate, the necessary equipment and aids needed for this performance should be mentioned, along with the standard acceptable performance, a range for this performance, and in some cases, a time limit. An example of such an objective is as follows:

Given 28 unmounted natural teeth, the student will be able to identify ten (10) specific teeth within a period of five (5) minutes.

Performance: identify

Equipment and aids: 28 natural teeth

Standard of acceptable performance: ten (10) teeth

Range of performance: 28

Time limit: within five (5) minutes

By stating the information and skills to be learned in behavioral terms, direction and purpose are added to the design of the instructional materials. In addition, objectives provide a means for test construction in order to assess whether or not the material presented accomplished the desired outcome. Furthermore, the students benefit in knowing exactly what is expected of them.

STEP 2: DESIGN

Having determined *what* information you want to present, you must now decide *how* you are going to present it. The design of your instructional product involves selecting the most appropriate methodology. Since one method of presentation may be more effective than another, care must be taken in this selection process. The question is, "Where does one start?" Perhaps the best advice we have to offer is to strive for: "the highest quality production, providing the greatest educational value, for the least amount of money, in the shortest amount of time."

For example, after a careful examination of your objectives, you may decide that color and motion are relevant cues for learning in your instructional product. But which method would most effectively accomplish your desired outcome? While color video tape, 16 mm. film, or 8 mm. film would for the most part be equally effective in providing the necessary cues, practicality might eliminate one or two of these methods due to cost, time limits or media characteristics. For example, while a 16 mm. motion picture might be highly desirable due to the large screen projection capability, the person-

nel, facilities, cost and time involved in such a production may eliminate this method as a possible choice.

It is suggested that a text discussing the characteristics of the various media be used to assist you in determining which methodology or approach would best fit your instructional needs.^{1,2,3}

Having selected the most appropriate methodology for meeting your objectives, the initial version of the instructional product is prepared. It is suggested that a script format be used for this purpose. This involves dividing an 8½ x 11" piece of paper into two columns, separating the audio and visual portions of the product. This enables you to examine both aspects of the script simultaneously, insuring that one portion coincides with the other. Furthermore, through frequent references to the behavioral objectives during scripting, appropriate revisions can be made, maintaining the proper focus on the instructional product.

STEP 3: EDITING

The editing step involves reviewing the initial version of the script with other specialists. This is often helpful because the instructional designer usually becomes so involved in his work that it is difficult to evaluate it objectively. This procedure includes an analysis of the content, organization, development, and visuals in accordance with the behavioral objectives. Suggestions for revisions are made at this time in a further attempt at designing a "quality" instructional product.

Based on these suggestions, information is added or deleted from the initial version. In addition, particular attention is given to all visually presented material to insure that proper standards for technical quality have been maintained.

STEP 4: DEVELOPMENTAL TESTING

This step of the production process involves testing the "rough" version of the instructional product with students representing a small sample of the intended audience. It is recommended that only one student be tested at a time, and that his comments, responses, and reactions be recorded.

After a careful analysis of this information, the necessary revisions are made, and the product is retested using a new student. This procedure is repeated and the product revised accordingly until the point is reached where numerous students are able to master all of the objectives.

Again, as in previous steps, frequent reference should be made to the behavioral objectives. This may result in slight revisions in other steps of the production process. These revisions are necessary, however, in tailor-making the instructional product for the intended audience.

STEP 5: VALIDATION TESTING

During the fifth and final step of the instructional design and development process, the product is presented to the intended audience and its overall effectiveness is examined. This involves a measurement between what the student *should know* according to the be-

havioral objectives, and what he *actually knows* based on his terminal performance. This data can readily be obtained by a slight rewording of the behavioral objectives into a testing format. For example, the objective previously stated in the Task Analysis read:

Given 28 unmounted natural teeth, the student will be able to identify ten (10) specific teeth within a period of five (5) minutes.

Stated orally, in a testing format, the objective may be presented as follows:

Out of the 28 natural teeth provided, you are to name 10. You have five (5) minutes to do this. Begin.

Should the intended audience master the objectives set forth for the instructional product, the effectiveness of the product is validated. It is suggested that in reporting these results the following information be included:

1. a description of the students involved in validation testing;
2. the conditions under which the product was used;
3. the measured results in the student's achievement;
4. the amount of time required to fulfill the objectives.

This information would enable the instructional product to be used by others having similar needs and conditions.

In this step of the instructional design and development process, only slight revisions should be necessary for all major revisions should have been made during the Developmental Testing Step.

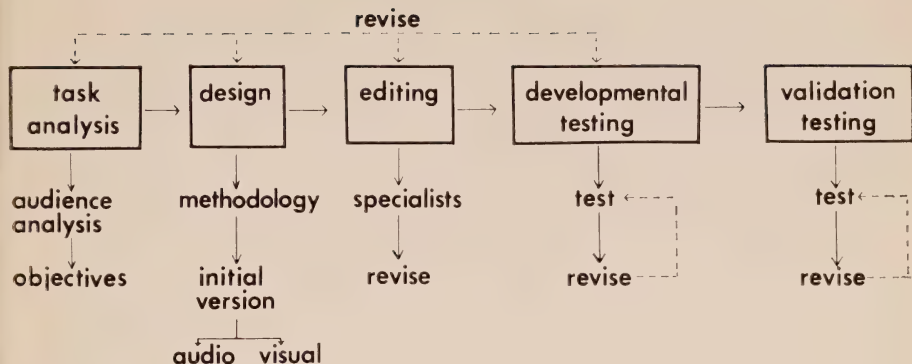


Figure 1. A model for the design and development of quality instructional media.

It is important to keep in mind that several exposures to the instructional product may be necessary to accomplish the objectives. More often than not, this will reflect the individual differences within the learners and not flaws within the product. However, care should be taken to record such information in order to pinpoint the problem area(s).

SUMMARY

In the past, many decisions regarding the preparation of "quality" instructional materials have been made on an intuitive basis. Unlike the traditional methods used in the production of instructional materials, the University of Maryland School of Dentistry uses a "systems approach." This approach follows an instructional

model consisting of the following five (5) steps: (1) Task Analysis; (2) Design; (3) Editing; (4) Developmental Testing; and, (5) Validation Testing. Such a model provides (1) extreme care in each step of the design and development of instructional materials; and (2) maintains a constant focus on the performance of the learners.

Only through a systematic approach of this nature can an instructional product be designed and developed that is truly "quality" in all senses of the term. The quality of instructional media can always be improved, but to do so, steps must be taken all along the line from origin of the idea to the utilization in instruction, and not simply at the production stage.

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Reconstituted Collagen Xenografts Preliminary Immunologic Observations

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Reconstituted Collagen Xenografts Preliminary Immunologic Observations*

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SUMMARY

Reconstituted bovine collagen xenografts were crosslinked with formaldehyde and glutaraldehyde and implanted into surgically created defects in rabbits. Healing was uneventful, and four weeks after implantation there were no signs of rejection. Humoral antibody was produced in animals hyperimmunized with a soluble collagen preparation and Freund's complete adjuvant. Immunological responses as measured by gel diffusion and delayed skin testing were negative in all experimental animals.

INTRODUCTION

Among the many materials currently being investigated for medical and surgical use as a possible replacement for bone, collagen appears to have the most desirable traits; i.e., bioacceptable, biodegradable, and readily available. "In view of the observation that collagenous proteins may be immunologically active, possible immunological effects have to be considered whenever such materials are clinically administered" (O'Dell, 1968).

Early investigators have reported failure to produce antisera to collagen and gelatin (O'Dell, 1968), others have reported weak antigenic properties (Watson, Rothbard & Vanamee, 1954), and several have produced antisera in rabbits to a variety of collagen preparations which react in complement fixation and passive hemagglutination tests (Kirrane, 1968; Steffen et al, 1970; Wolff et al, 1970; Rothbard & Watson, 1972; Timpl et al, 1970; Schmitt et al, 1964; Nishihara, 1964; Adelman, 1973). Recently, calf skin collagen has also been observed to induce a delayed hypersensitivity response in guinea pigs (Adelman, 1973).

The majority of antisera to collagen has been the result of hyperimmunizing animals intramuscularly and subcutaneously with collagen preparations and Freund's complete adjuvant (4-10). Rubin et al. (1968) reported the inability to detect antibody activity to collagen in the serum of animals after intravenous injection of soluble collagen.

Thus the question arose as to the antigenicity of a cross-linked

*This investigation was supported in part by the Office of Naval Research, Contract #N 00014-73-A-0337-0002.

collagen calf skin preparation when implanted into the mandibles of rabbits. The purpose of this preliminary study was to determine, by gel diffusion and delayed skin testing, the immunological responses in rabbits to a bone graft material made from a reconstituted calf skin collagen preparation.

MATERIALS AND METHODS

Fresh calf skin was obtained and collagen extracted in 0.5 M acetic acid, cleared, reconstituted by dialyzing against 0.4 M phosphate buffer pH 7.6, and cross linked with 1.33 M formaldehyde or 1.33 M glutaraldehyde. Details of this procedure have been previously published by DeVore (1973).

Two groups of 6 rabbits each were anesthetized, bled, and were given bilateral segmental resections of the mandibles. One group had defects filled with formaldehyde fixed collagen and the other group with glutaraldehyde fixed collagen. Two animals were operated and left ungrafted as a control. One half of each group was bled and sacrificed at 1 week post surgery, and the remaining animals were sacrificed at 1 month.

Two additional rabbits were immunized with a soluble collagen preparation (SbCp). The acid extracted collagen was centrifuged to remove insoluble material and dialyzed in isotonic saline. It was passed through a 0.45μ filter and was found to contain 750μ g protein/ml by the Lowry assay. The rabbits each received a series of 3 weekly injections, the first two containing 350μ g antigen (0.5 ml) and 0.5 ml Freund's com-

plete adjuvant given in 0.2 ml/injection site. The last injection consisted of an IP booster of only the soluble collagen preparation (350μ g). The rabbits were ear bled on the eighth day following the last injection and the sera prepared for gel diffusion testing. One other rabbit was immunized with calf serum and Freund's complete adjuvant following the schedule previously mentioned.

Delayed Hypersensitivity Testing.

The soluble collagen preparation (75μ g) was injected intracutaneously on the shaved lower back of the animals which had received collagen implants. The delayed skin testing occurred 3 days before sacrifice of the implanted animals. The injection site was circled and checked for erythema and induration at 4, 8, 24, 48, and 72 hours.

Gel Diffusion Testing.

Each gel diffusion dish contained six peripheral and one central well with a center to center distance of 1.5 cm. Two plates were utilized for each experimental animal, one containing peripheral wells with two fold dilutions of sera and the soluble collagen preparation in the central well, the other dish containing just the reverse. Plates were incubated at 4° C and checked daily for precipitin lines. Staining was performed with 0.25% Nigrosin in methanol acetic acid (9:1) after removal of non-precipitating protein by washing in saline.

RESULTS

The implanted collagen xenograft can be observed in Figure 1.

All animals grafted with either the formaldehyde or glutaraldehyde cross-linked collagen healed uneventfully with no signs of infection or rejection (Fig. 2).

The antiserum from two rabbits immunized with SbCp and Freund's complete adjuvant formed a single precipitin line when reacted in gel diffusion with the SbCp antigen (Fig. 3). The serum from the animal immunized with calf serum displayed several precipitin lines when reacted with calf serum, however no lines were observed upon reaction with SbCp.

Serum from rabbits bled after glutaraldehyde and formaldehyde cross-linked collagen implants of one and four weeks durations failed to show any precipitin lines when reacted with SbCp as antigen. Similarly, delayed skin tests were negative in all collagen implanted animals.

DISCUSSION

The SbCp was immunogenic when injected into rabbits with Freund's complete adjuvant. Only one line appeared upon reaction with the antiserum and SbCp, suggesting one predominant antigen in the SbCp. The lack of reaction with the serum from the rabbit immunized with calf serum suggested the SbCp did not contain detectable calf serum proteins.

The inability to detect antibody in the animals after reconstituted collagen implants could be due to: (1) the degraded implant material not serving as an immunogen; (2) a decrease in antigenicity af-

ter cross-linking of the collagen implant material; (3) the inability to detect anti-collagen antibody as long as collagen is still present in the animal unresorbed; and (4) the sensitivity of the gel diffusion test.

Grillo and Gross (1962) reported that reconstituted acid soluble calf skin collagen when implanted into the soft tissue of rabbits degraded within 4-5 weeks and was then replaced by host fibrous tissue. They stated their collagen preparation to be poorly antigenic and felt that the antigenicity of their preparation was possibly due to contaminating plasma proteins. We are aware of possible contaminating proteins in the SbCp and current studies entail amino acid analysis and isoelectric focusing to determine the purity of the SbCp.

Along with these studies, efforts are being placed in the measurement of antibody levels to collagen with complement fixation testing, testing immune responses at times after complete graft resorption and re-implantation, and the implantation of grafts in hyperimmunized rabbits as well as in primates.

In summary, the SbCp was immunogenic when injected into rabbits with Freund's complete adjuvant. Double diffusion in agar and delayed skin testing failed to reveal immunological responses in rabbits one and four weeks after xenogeneic collagen implants. At four weeks after implantation, no signs of infection or rejection could be observed.

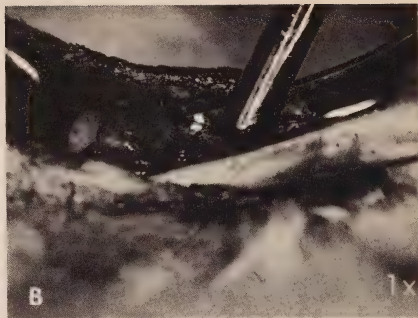


Figure 1.

A.) Rabbit mandible with section removed. B.) Collagen graft in place.

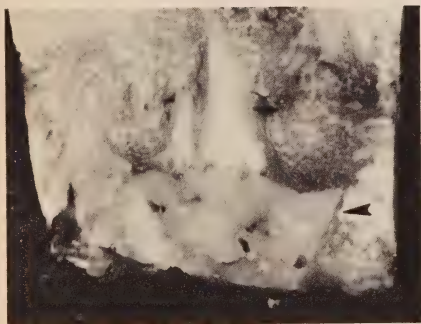


Figure 2.

Cross section through bone showing one month gluteraldehyde cross-linked graft.



Figure 3.

Double diffusion in agar. Well A, undiluted SbCp. Well B, undiluted rabbit anti-SbCp.

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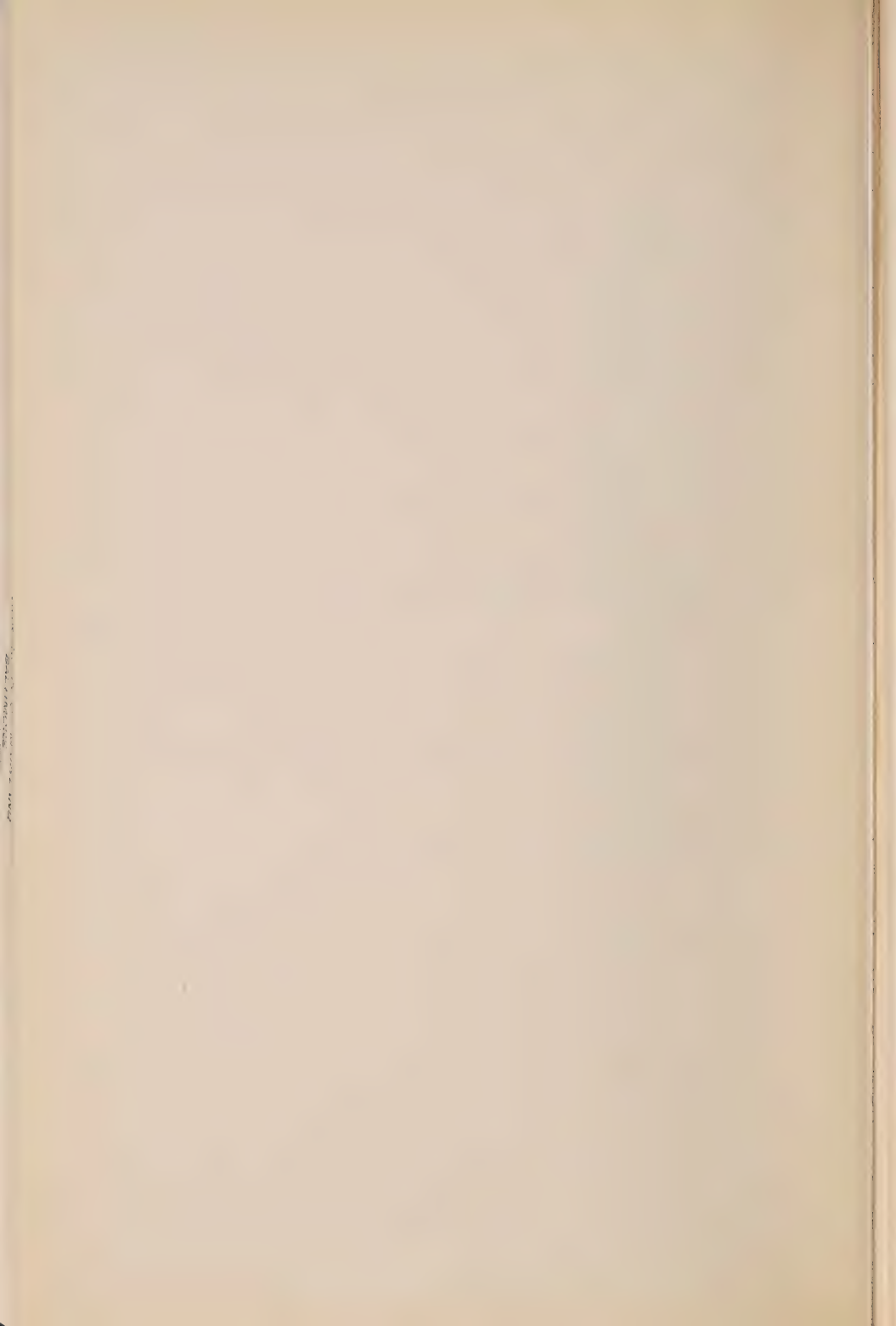
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The Kinetics of Chloride and Thiocyanate Effects on Acid Secretion in the Frog Gastric Mucosa

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The Kinetics of Chloride and Thiocyanate Effects on Acid Secretion in the Frog Gastric Mucosa

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SUMMARY

1. Acid secretory rate (J_H) and short circuit current (J_{sc}) can be measured in the bullfrog gastric mucosa. From these values, total chloride flux (J_{Cl}) can be calculated. The validity of this calculation does not depend upon the mechanism assumed for active transport of H^+ and Cl^- .

2. Determinations of J_H , J_{sc} and J_{Cl} as functions of the concentration of Cl^- in the bathing media (with and without 1 mM NaSCN) and as functions of $[SCN^-]$ at full chloride give simple kinetics for J_H and J_{Cl} , but anomalous results with large scatter for J_{sc} . It is concluded that J_H and J_{Cl} measure active transport activities, while J_{sc} has no mechanistic basis, being merely J_{Cl} minus J_H .

3. The electrogenic pump hypothesis predicts that J_H and J_{Cl} measure mechanisms; the competing unitary pump hypothesis predicts that J_H and J_{sc} measure mechanisms. Thus, the data are most easily fit by an electrogenic

model, in which both J_H and J_{Cl} are Michaelis functions of $[Cl^-]$ with different kinetic parameters.

4. Attempting to fit the data to the unitary pump hypothesis also requires two pumps (for J_{HCl} and J_{sc}) with different kinetic constants, but requires additional postulates to explain the lack of consistency of the J_{sc} data and the negative values for J_{sc} observed at low $[Cl^-]$. In addition, a stimulatory effect of SCN^- on the electrogenic Cl^- pump must be assumed. The complexity of the required assumptions makes the unitary hypothesis less favorable.

5. Thus these data, with others from the literature, support the concept of separate, electrogenic H^+ and Cl^- active transport systems as the mechanism for acid secretion in the stomach.

INTRODUCTION

It is well established that the gastric mucosa of the frog transports both H^+ and Cl^- by active processes from the serosal to the mucosal surface (8,18), with Cl^-

transport in excess of H^+ transport under short circuit conditions, giving rise to a short circuit current (2,8). Other ion transports are negligible under usual conditions (3). Two fundamentally different models have been proposed to account for these transports. The electrogenic pump model, or separate site hypothesis (18), proposes that H^+ and Cl^- are moved by separate pumps, both located in the mucosal membrane of the cell, which may share some common metabolic machinery but are not constrained to operate at any fixed ratio. An alternative scheme envisions an electrically neutral mechanism which transports HCl into the mucosal solution. This is called the unitary pump mechanism (6). In the latter scheme, one must also postulate an additional electrogenic Cl^- pump to account for the excess of Cl^- transport over H^+ , which is the source of the short circuit current. Evidence has been presented for both models, and the distinction is important for any subsequent understanding of the molecular basis for gastric acid secretion.

As Hogben (8,9) has shown, the total net flux of Cl^- across the bullfrog gastric mucosa under short circuit conditions can be accounted for by the sum of the hydrogen ion transport rate (J_H) plus the short circuit current (J_{sc}), implying that no other ion is significantly transported across this tissue. Thus, we can measure J_H by titration, J_{sc} by conventional means, and calculate J_{Cl} , the total chloride net flux. In the electrogenic model, J_H and J_{Cl} have a physical reality, being the activities of the two pumps, while J_{sc} is merely the difference between these activities, and does not measure a mechanism. In the unitary

pump model, however, J_H measures the activity of the HCl pump, J_{sc} measures the activity of the additional electrogenic pump, and it is J_{Cl} which has no mechanistic basis, being just the sum of the other two. Real transport mechanisms might be expected to obey rational kinetic principles, while quantities which are constructed from sums and differences of other activities might be expected not to conform. These considerations provide the basis for the experiments to be reported.

METHODS

The gastric mucosa of the bullfrog (*Rana catesbeiana*), stripped of its external muscle coat, is mounted as a flat sheet (4.91 cm² area) between fluid-filled chambers. Gas lifts and external reservoirs provide sufficient fluid circulation to avoid unstirred layer problems (12). Under control conditions, the fluid in contact with the serosal surface of the tissue was a modified Ringer's solution containing (mM): Na^+ , 104; K^+ , 4; Ca^{2+} , 1; Mg^{2+} , 0.8; Cl^- , 82.6; HCO_3^- , 25; phosphate, 2; glucose, 20; histamine, 0.1. The mucosal solution contained the same components with the exception of glucose, histamine, phosphate and bicarbonate, the latter two being replaced with SO_4^{2-} to maintain equal Na^+ and Cl^- concentrations. Both surfaces were gassed with 10% CO_2 in O_2 to achieve maximum secretory rates (13), which results in a serosal pH of about 7.1. Under these conditions, the average acid secretory rate for the tissues used in this study was $5.06 \pm 0.28 \mu Eq/cm^2 \cdot hr$ ($\pm SEM$).

Hydrogen ion secretory rate (J_H) was measured by the pH-stat method, titrating to pH 4.5 with

0.01 N NaOH to avoid errors caused by bicarbonate formation (21). Potential difference (PD) was measured by fiber junction calomel/KCl electrodes in the fluid paths on both surfaces. Short circuit current (J_{sc}) was measured by passing current from an external source to bring the PD to zero

(correcting for the resistance of the fluid between the electrode tips), and is reported in units of $\mu\text{Eq}/\text{cm}^2\cdot\text{hr}$.

For each tested condition, the tissue was equilibrated for a one hour period with the indicated solution. During the last 12 minutes

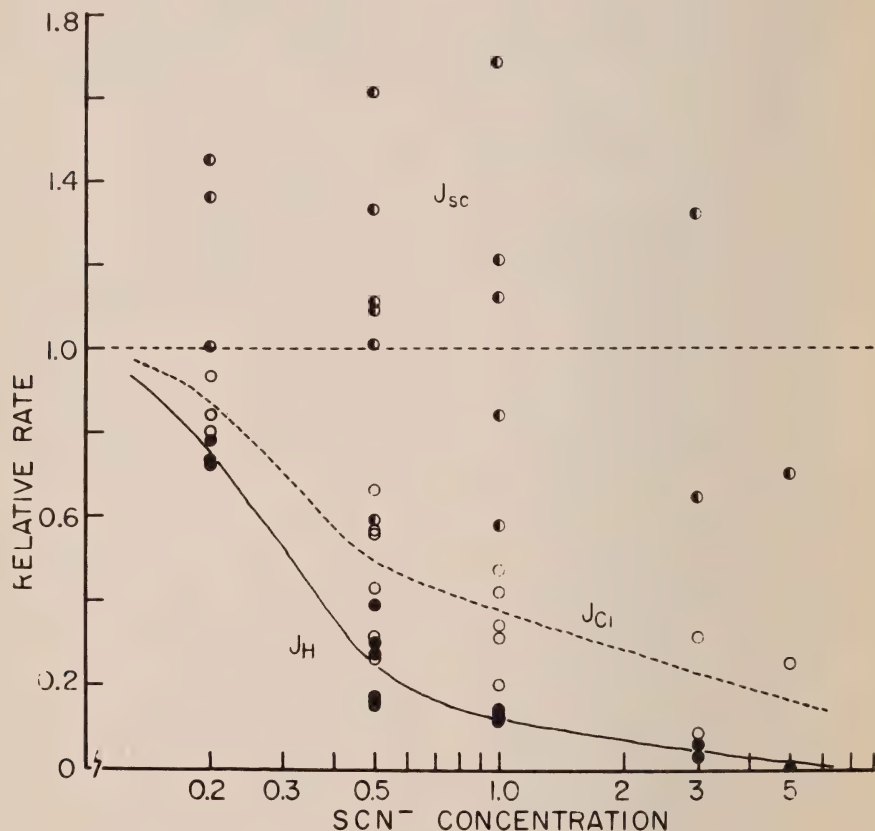


Figure 1.

Inhibition of the measured fluxes by NaSCN, plotted on a log scale for convenience only. The inhibitor was added to both bathing solutions, and the rates calculated for the period 56-60 minutes after addition. All fluxes are normalized to the uninhibited rate determined on that same tissue, so all curves would pass through 1.00. Solid dots and curve, J_H ; open circles and dotted curve, J_{C1} ; half-filled circles with straight line for comparison, J_{sc} . Note the tight grouping of points representing J_H and J_{C1} , but considerable scatter of the J_{sc} points, many of which fall above the line of no inhibition.

of the period, the tissue was short circuited, and the values of J_{sc} and J_H were determined during the last 4 minutes of the period, which allows 8 minutes for the "long time constant transient" to settle to its final value (14). Solutions were then changed and this procedure repeated. Usually 5 such periods were measured on each tissue.

Reduced chloride concentrations were achieved by replacing SO_4^{2-} for Cl^- in both solutions, maintaining other ions constant, and correcting the osmotic deficit with sucrose. When NaSCN was used, it was added to both solutions in the indicated concentration, which causes a minor rise in the Na^+ concentration.

Tissues from different frogs have different total activities, due in part to differences in the number of secreting units per unit gross area. Therefore, all fluxes were normalized to the control J_H value for that tissue, and the data are reported in this form. The double reciprocal plots were made by plotting $1/\text{rate}$ vs. $1/[Cl^-]$, fitting the best straight line to the data, and determining the kinetic coefficients from the coefficients for the equation for that line (20).

RESULTS

The effect of SCN^- on the gastric mucosa under control chloride conditions (82.6 mM) is shown in Fig. 1. The SCN^- concentration for 50% inhibition of J_H is about 0.3 mM, which is 1/2 to 1/10 of the doses previously reported (5, 15). These tissues secreting at maximum rates (with 10% CO_2) are more sensitive to SCN^- than under previous conditions, as would

be expected since they are less likely to be rate limited by external conditions (13). Total chloride flux, J_{Cl} , is also inhibited by SCN^- , and both fluxes show smooth inhibition curves with little scatter. By contrast, J_{sc} is inhibited at higher doses of SCN^- , but is apparently stimulated by lower doses, and is so inconsistent in its response that no curve is drawn. This stimulation of J_{sc} by SCN^- has been reported previously (19).

Stepwise reduction of Cl^- concentration, in the absence of SCN^- , gives the results shown in Fig. 2. J_H , J_{Cl} and J_{sc} are all seen to be functions of the Cl^- concentration, and the first two seem to obey saturation kinetics (the lines are drawn on that assumption). We see, however, that J_{sc} reverses in sign at low Cl^- , becoming nearly equal to the hydrogen ion rate in the total absence of Cl^- , as reported by Heinz and Durbin (7). This result supports the concept of electrogenic production of H^+ under these conditions. It can be argued that the extreme condition of zero Cl^- has uncoupled a pump which is normally coupled. For this reason, and since low levels of SO_4^{2-} and SCN^- active transport have been demonstrated in this tissue (10, 11), and since the precision of measurement becomes poor at the low resulting rates, it was felt advisable to restrict the kinetic analysis to Cl^- concentrations above 10 mM. This removes most of the negative J_{sc} values from the following calculations.

The form of the curves in Fig. 2 suggests that they might be the result of some process obeying a kinetic similar to that of simple enzyme systems. Accordingly, plots

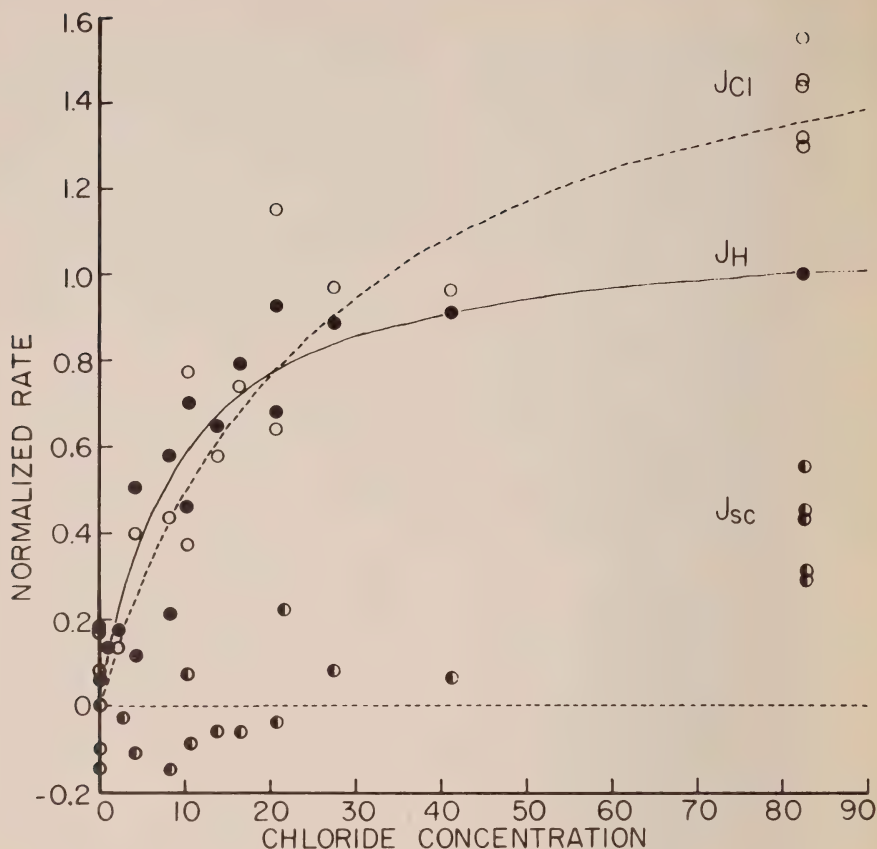


Figure 2.

Plot of normalized (to J_H) rates vs. chloride concentration in both bathing solutions. As in Figure 1, the solid dots and solid curve represent J_H ; the open circles and dotted curve are J_{Cl} , while the half-filled circles are J_{sc} . The curves are calculated from the kinetics determined later. No line is fit to the J_{sc} values; note that, at low Cl^- concentrations, many values are negative. The control point at $J_H = 1.00$ is the base for normalization.

of $1/J_H$ and $1/J_{Cl}$ against $1/[Cl^-]$ were produced, which are shown in Fig. 3. The agreement of the data to the predicted straight line is reasonable ($r=0.85$ and 0.86 for the lines shown) and we can use these lines to determine the kinetic constants. The Michaelis (16) constant for the acid secretory rate,

K_H , is 9.17 mM, while J_H^{max} , the (extrapolated) rate at infinite chloride concentration, is 1.11 (11% above normalized control). Likewise, for total chloride flux, K_{Cl} is 26.9 mM, and J_{Cl}^{max} is 1.79 . The two K 's are different, and the fit to the electrogenic model, which this analysis implies, is reasonable.

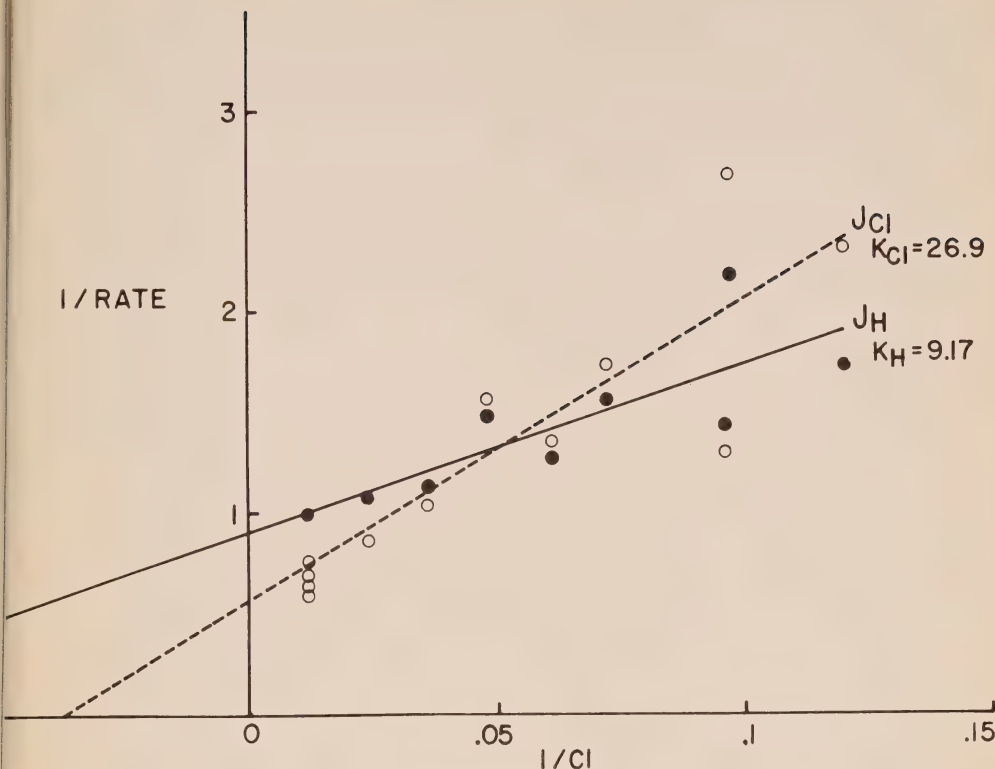


Figure 3.

Double-reciprocal plot of the data in Figure 2, excluding the points for $[Cl^-]$ less than 10 mM (see text). The lines are fitted by the method of least squares, and the constants determined from the resulting equation.

When the double reciprocal plot of $1/J_{sc}$ vs. $1/[Cl^-]$ is attempted, the best fit line has a correlation coefficient of -0.31 ; we cannot draw this plot in the usual enzyme kinetic manner. Elimination of the negative values for J_{sc} raises the correlation coefficient to 0.56 , but this leaves only 8 data points, of which 4 are at control chloride concentration. It appears that J_{sc} is not amenable to treatment by this analysis.

When chloride concentration was changed in the presence of 1 mM NaSCN, the resulting J_H and J_{Cl} values can be used to construct Fig. 4 and 5. We see that the data points still define straight lines ($r = 0.91$ and 0.96) but that both the slope and intercept of these lines is changed. From these values and those of the control tissues, we can calculate the dissociation coefficient of the carrier-inhibitor complex (if this is the

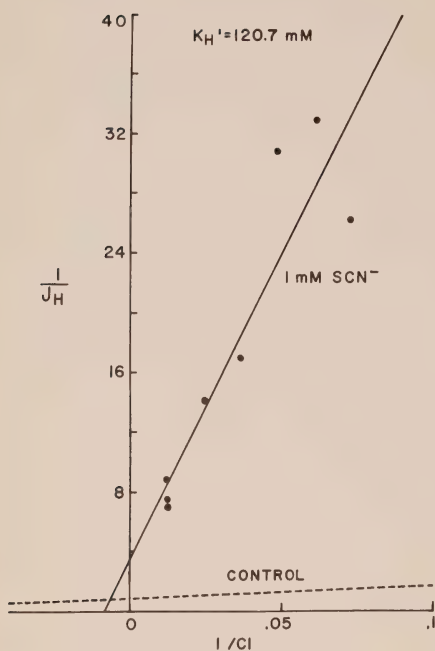


Figure 4.

Double reciprocal plot of hydrogen ion secretory rate (J_H), in the presence of 1 mM NaSCN in both solutions. Note the large change in apparent K_H caused by SCN^- , as compared to Figure 3.

mechanism), since one can show that this coefficient, K_i , is related to the K values by the expression (20) $K' = K(1 + 1/K_i)$, where K' is the apparent K with the inhibitor present at concentration I , here 1 mM. Thus, K_i for H^+ secretion is 0.082 mM, while that for Cl^- is 2.56 mM, over 30-fold higher. Thiocyanate is therefore a much more effective inhibitor of hydrogen ion than of chloride transport, assuming the electrogenic model as before. The plot of $1/J_{sc}$ v. $1/[Cl^-]$ in the presence of 1 mM SCN^- can be also be fit

by a straight line, as would be expected since J_{Cl} is known to fit, while J_H is now very small, and $J_{sc} (= J_{Cl} - J_H)$ thus approximates the kinetics of J_{Cl} under SCN^- inhibition.

The results tend to the conclusion that J_H and J_{Cl} can be analyzed as smooth curves of simple kinetics, while J_{sc} is not generally well behaved in these analyses.

In all of the experiments reported, returning the tissue to control conditions (removal of SCN^- and/or return to high Cl^- conditions) causes a return of the meas-

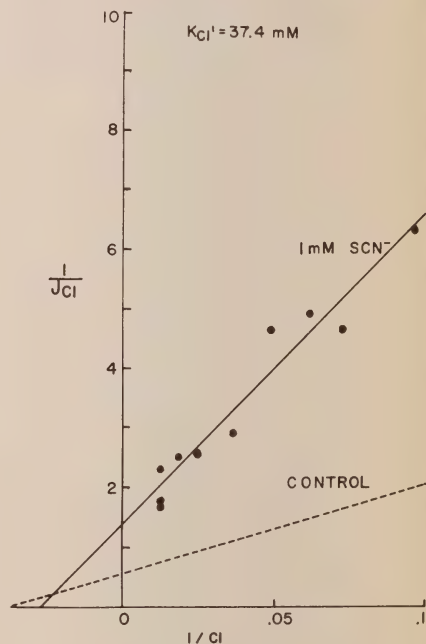


Figure 5.

Double reciprocal plot of the total chloride secretory rate, J_{Cl} , in the presence of 1 mM NaSCN. The increase in apparent K_{Cl} is moderate compared to that for K_H .

ured parameters toward their control values, but the reversal is seldom complete. The reason for this failure is not known, but it implies a time dependent effect in addition to the mechanisms proposed, and probably accounts for much of the variability in the data.

DISCUSSION

Regardless of the pump mechanism assumed, active H^+ and Cl^- transport will be coupled under certain conditions. If these are the only two ions capable of crossing the tissue, it is clear that under open circuit conditions electroneutrality requires that $J_H = J_{Cl}$. Thus the demonstration of equality of J_H and J_{Cl} under these conditions (4) does not constitute evidence for or against a unitary mechanism. When the tissue is short circuited, as in these experiments, electrical coupling no longer exists for the tissue as a whole, and independent pumps may work at different rates.

Even under these conditions, the pumps must be coupled to some extent by sharing common biochemical mechanisms. If one pump produced, as a byproduct, a necessary substrate for the other pump, which was not available from another source, we might find transient periods in which $J_H \neq J_{Cl}$, but in the steady state these fluxes must be equal. Usually, however, we might expect looser coupling, as a consequence of common energy requirements, if nothing else. Thus, even completely independent electrogenic pump mechanisms should be coupled to some degree.

These extrinsic coupling mechanisms are to be distinguished from the intrinsic coupling implied by

the unitary pump hypothesis, in which the cotransport of H^+ and Cl^- is a requirement of the pump mechanism itself. Although the rate of this pump may vary with conditions, it should remain coupled under all but (perhaps) extreme conditions. While it is possible to imagine a coupled pump with a continuously variable coupling ratio, which could be modulated to fit any data, this seems inordinately complex compared to simple electrogenic or simple unitary systems, and we will exclude such a pump from consideration until it can be shown that neither simple system will explain the results.

As we have seen, the present experiments are directly interpretable according to simple enzyme (or carrier) kinetics, if one assumes independent H^+ and Cl^- mechanisms, each with a dependence upon Cl^- concentration. Since we have limited our kinetic exploration to Cl^- concentrations between 10 and 82.6 mM, we can be sure of the kinetics only over this range.

As reported by Heinz and Durbin (7), and shown on Fig. 2, there is an appreciable acid secretory rate with no chloride in the bathing solutions, which would not be predicted from the kinetics which apply to the higher Cl^- concentrations. However, it appears that bathing a tissue in Cl^- -free medium for one hour will not remove all of the Cl^- from the tissue. From K_H and J_H^{max} determined at higher concentrations, we could explain the average normalized acid secretory rate in Cl^- -free medium ($J_H = 0.15 \pm 0.03$) if the Cl^- concentration available at the pump site were 1.43 mM. Shanbour and

Rehm (22) have reported finding 6.7 mEq Cl^- per Kg tissue water in *R. pipiens* gastric mucosa under similar conditions, so it is quite likely that our calculated figure could exist. If 1.43 mM Cl^- is retained in the cells under Cl^- -free bathing solutions, we calculate from the kinetic coefficients for the Cl^- system that a flux of Cl^- of 0.09 (normalized units) should exist. This value is too small to be determined with precision, as we measure 0.055 ± 0.013 , a value barely different from zero at the 5% confidence level. Thus, it is not necessary to postulate that the hydrogen ion pump be able to function in the complete absence of Cl^- , although one must conclude that the required Cl^- is not transported from the system, as the quantities available are not sufficient for the sustained secretion that can occur (22).

The data reported can be fit to a unitary pump mechanism, but considerable circumvolution is required, and even then the results are not satisfactory. In the unitary model, J_H would be the measure of the activity of the coupled HCl pump, and as we have seen, K_H and J_H^{\max} can be obtained. J_{sc} did not plot satisfactorily, but we can determine what value it must have in order to fit the relationship $J_H + J_{sc} = J_{Cl}$. If we assume that J_{sc} follows a Michaelis kinetic (16), we can write that:

$$J_{Cl} = J_H + \frac{J_{sc}^{\max} S}{K_{sc} + S}, \quad (1)$$

from which

$$K_{sc} = \frac{S (J_{sc}^{\max} - J_{Cl} + J_H)}{J_{Cl} - J_H}. \quad (2)$$

Since

$$J_{sc}^{\max} = J_{Cl}^{\max} - J_H^{\max}, \quad (3)$$

then

$$K_{sc} = \frac{S (J_{Cl}^{\max} - J_H^{\max} - J_{Cl} + J_H)}{J_{Cl} - J_H}. \quad (4)$$

At any given S , for instance the control value, 82.6 mM (for which most data points are available) we can solve Eq. 4. Where $S = 82.6$ mM, $J_H = 1.00$, $J_{Cl} = 1.41$, $J_{Cl}^{\max} = 1.79$ and $J_H^{\max} = 1.11$, then $K_{sc} = 69.2$ mM. This value, the K for the "extra" electrogenic chloride pump required by the unitary hypothesis, is rather high but not impossible. Further, although Equation 1 does not predict a straight line on a double reciprocal plot, the difference is not sufficient, with the coefficients determined, to give a worse fit to the somewhat scattered data available. This method does, however, require us to assume a straight line relationship between $1/J_{sc}$ and $1/[\text{Cl}^-]$; as we have seen, the data do not support this assumption.

When we attempt to include the effects of SCN^- on the unitary model, we have real problems. Applying the above reasoning to the inhibited values, we obtain a value for K'_{sc} , the apparent constant in the presence of 1 mM SCN^- , of 24.8 mM. This is less than half of the value in the uninhibited case. If this is not a spurious value from accumulated errors, we would have to conclude that the electrogenic Cl^- pump in this model has a higher affinity for Cl^- in the presence of SCN^- than in its absence. While this is possible, it constitutes an additional postulate to be in-

cluded in the model. It is, however, consistent with the data in Fig. 1 showing a stimulation of J_{sc} at low levels of SCN^- .

Finally, we must deal with the negative J_{sc} values observed at low Cl^- concentrations. In the unitary model, these could be due to 1) a reversal of the electrogenic Cl^- pump at low Cl^- concentrations, 2) some other ion transport besides H^+ and Cl^- under these conditions, or 3) a unitary pump which becomes uncoupled at low Cl^- concentrations, resulting in an electrogenic H^+ transport under these conditions. The last of these seems the most likely, and is the usual explanation, but requires yet another postulate (that of uncoupling below some critical Cl^- concentration) to be added to the model.

At this point, it seems that we should apply the rule of simplicity and return to the electrogenic model, which gives a direct and satisfactory kinetic explanation of the data. Provided only that both J_H and J_{Cl} are simple pump activities, functions of $[Cl^-]$, and inhibited by SCN^- , we can explain the dependence of J_H and J_{Cl} on

$[Cl^-]$, the SCN^- inhibition data, the existence of negative J_{sc} values, and the wide scatter of J_{sc} values, which do not obey rational kinetics since they are not measures of pump activities. Without any discontinuity in the kinetics of any pump, we can explain the persistence of acid secretion in chloride-free solutions, if the persistence of some cellular chloride is allowed. Finally, this theory seems best suited to the explanation of other data, such as the effects of current on the hydrogen ion secretory rate (the "Rehm effect") (1, 17) and the observation of LeFevre *et al* (15) that in chloride-free media there is an exact linear relationship between J_H and PD.

Ultimate proof of the nature of the pump mechanisms must await the isolation of the machinery involved. The present data contribute to the prediction that separate, electrogenic H^+ and Cl^- mechanisms will be found.

ACKNOWLEDGEMENTS

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The Prevalence of Pyogenic Granuloma In Pregnant Women

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The Prevalence of Pyogenic Granuloma In Pregnant Women

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SUMMARY

1. The article consists of a review of the literature and a study of the gingivae of four hundred and seventy-seven pregnant women and two hundred thirty-three non-pregnant women.

2. It was found that 9.6 per cent of the pregnant women and 1.7 per cent of the non-pregnant women had discrete enlargement of the interdental papillae. The prevalence of "pregnancy tumor" in this clinical study was 0.8 per cent.

3. It was found that statistically there was an association between pyogenic granuloma and pregnancy; however, the association was weak and more data is required.

INTRODUCTION

According to Shafer,²⁴ the pyogenic granuloma is a form of overgrowth of granulation tissue as an abnormal response of the tissue to a nonspecific irritant.

Despite the frequent occurrence of pyogenic granulomas in pregnant women, few studies have carefully connected the occurrence of pyogenic granuloma to the systemic changes during pregnancy.

The purpose of this study was to determine the prevalence of pyogenic granuloma in pregnant women and its association to pregnancy.

REVIEW OF THE LITERATURE

During pregnancy the gingiva may appear hyperemic and enlarged and bleed easily when traumatized by tooth brushing or mastication. Pregnancy gingivitis may occur as a generalized or localized condition.¹⁸ In the localized form the inflamed papilla is enlarged and forms a discrete tumor-like mass often called a "pregnancy tumor".²⁹ Kerr¹¹ doubted whether these tumors could be histologically differentiated from pyogenic granuloma.

Shafer et al.²⁴ believed that the pregnancy tumor is basically a pyogenic granuloma which appears about the third month of pregnancy or later and gradually increases in size. The lesion may regress after delivery.^{9, 24, 28}

In a variety of studies the incidence of "pregnancy tumor" varied between 0.2 per cent to 2.7 per cent. Tiilila²⁸ reported one case of "pregnancy tumor" out of 453 pregnant women or (0.2 per cent). Gridley⁷ reported 27 cases out of

1,002 patients or 2.7 per cent. Ziskin²⁹ found an incidence of 0.7 per cent and Maier²⁰ found it to be 0.5 per cent.

Lesions of an identical clinical and histologic nature are seen in men and in non-pregnant women.²⁴ It may be appropriate to say that the "pregnancy tumor" is a pyogenic granuloma occurring during pregnancy.⁴

Some investigators reported that there was no significant difference in occurrence of pyogenic granuloma between the sexes^{8, 24, 27} while some others found a slight tendency for the lesion to occur more frequently in females.^{3, 2, 5, 22} Kerr¹¹ found that the difference in sex incidence did not appear to be significant except in specific sites such as the gingivae. Of his sixty-four gingival lesions the sex was known in fifty-three; and thirty-nine lesions, or seventy-three per cent, were in females. This was significant because of the tendency of this lesion to occur in association with pregnancy gingivitis.²⁹

It seems that the age is not significant for pyogenic granulomas. Lesions have been observed in infants and elderly persons with no apparent predilection for any age group.^{2, 8, 11, 24}

Before 1925 it was believed that pyogenic granuloma originated as a result of botryomycotic infection,²¹ while later some believed that staphylococcus aureus had a role in causing the lesion¹¹

Recently it was stated that pyogenic granuloma resulted from some minor trauma which had provided a pathway for invasion of micro-organisms causing a charac-

teristic tissue response due to the low virulence of the organisms.^{11, 24} The response of the tissue toward these organisms was the proliferation of a vascular connective tissue.²⁴ Gram positive and gram negative cocci were present on the surface of the lesion but no organisms were observed at the base of the lesion.²⁵

Hare⁸ suggested that pyogenic granuloma is due to trauma and possible infection, while Tiecke²⁷ suggested that it was initiated by trauma superimposed upon certain systemic conditioning factors. The exact nature and relationships of these predisposing conditions are unknown.²⁵

Some investigators postulated that "pregnancy tumors" might be caused by calculus¹⁹ stimulating tissue reaction which was probably intensified by the endocrine alterations occurring during pregnancy.²⁴ It has also been suggested that "pregnancy tumors" have developed as a result of ingestion of an oral contraceptive.^{10, 13} Experimentally it was found that sex hormones induced tissue reaction and changes in the microvascular system.^{14, 17} It was also found that urine extract of pregnant females would induce epithelial hyperplasia of the gingiva when injected in monkeys.²⁹ Local application of estrogen, and to some extent progesterone, initiated vascular proliferation.¹⁵ A study of dogs indicated that the administration of estrogen and progesterone induced an increase in the flow of gingival fluid in gingivitis-free female dogs.¹⁶

Gingiva is the most common oral location for pyogenic granuloma^{2, 3, 11, 21, 24, 25} and it most frequently arose from interdental papilla^{3, 25}

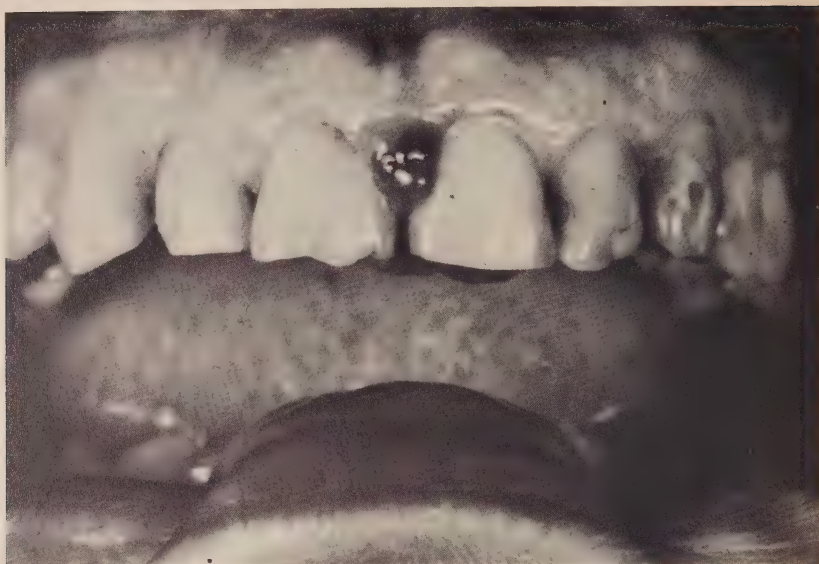


Figure 1: Pyogenic granuloma occurring on the gingiva.

(Fig. 1) It may also be found on the lips, tongue and buccal mucosa.^{11,21,24}

The majority of the intraoral pyogenic granulomas vary from a few millimeters to three centimeters.^{2,21,26} The lesion develops rapidly, reaches full size in a short time and remains for an indefinite period of time.⁸

Bhaskar and Jacoway⁴ reported that the largest pyogenic granuloma in their series was 3.5 by 6.0 centimeters, and they found no correlation between the size and duration of the lesion. Pyogenic granulomas have a spherical shape and are pedunculated or sessile. The surface is smooth but sometimes shows lobulations or even a somewhat warty appearance.^{2,21,24} It is bright red or purple in color depending on the age of the lesion,^{2,11,21} and the degree of vascularity

and congestion.^{11,24} Sometimes there is purulent exudation, but this is not a characteristic feature despite the suggestive name of this lesion.^{24,27}

The lesion shows a tendency for hemorrhage either spontaneously or upon slight trauma. If hemorrhage has occurred, the lesion becomes brown in color.^{11,21,24} Alexander¹ reported a case of pyogenic granuloma on the brow which caused acute and chronic blood loss.

The histologic appearance of pyogenic granuloma is similar to that of granulation tissue. The most constant and characteristic feature of the lesion is extreme endothelial and fibroblastic proliferation, budding of endothelial cells and formation of numerous vascular spaces.^{11,12,24,28} (Fig. 2 and Fig. 3) In many of the lesions the epithel-

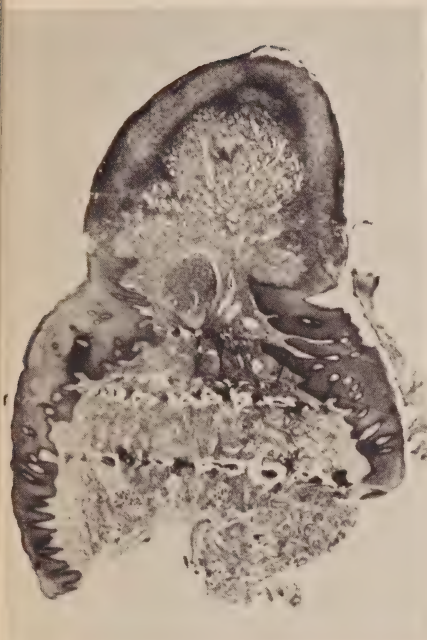


Figure 2: Low power photomicrograph of pyogenic granuloma covered by fibrinous exudate and showing numerous blood vessels. (10 \times)

ium over the central area is ulcerated and the surface is covered by fibrinous exudate. If there is ulceration there will be a heavy infiltration of inflammatory cells with polymorphonuclear leukocytes predominating.^{11, 24, 28}

Although one investigator⁵ suggests roentgentherapy, the treatment of choice for pyogenic granuloma consists of surgical excision with care being taken to remove all tissue around the base of the reaction.^{11, 24} Incomplete surgical excision will lead to recurrence.^{12, 24, 27} If the lesion is left without surgical treatment, it will heal spontaneously and produce a residual fibrous mass.^{12, 24}

In cases of pyogenic granuloma of gingiva that occur during pregnancy, the lesion may disappear completely following parturition.^{9, 28} Usually the regression is not complete and the lesion persists in the involuted state until the next pregnancy, when it is again stimulated to grow.^{11, 28}

The prognosis of pyogenic granuloma is very favorable. It is not an infiltrative lesion and has no malignant potentiality.³

METHOD OF INVESTIGATION

Four hundred and seventy-seven pregnant women and two hundred forty-nine non-pregnant women were examined in the Obstetric and Gynecology Clinics at the University Hospital in Baltimore. Out of the 249 non-pregnant women, sixteen were excluded from the study because they were over forty-two years of age or had an oophorectomy leaving 233 non-pregnant women in the study.

The oral hygiene and periodontal indices were recorded according to Green and Vermillion and Russell respectively.^{6, 23}

FINDINGS

Of the 477 pregnant women there were forty-two (9.6 per cent) who had discrete enlargement of the interdental papillae. Four of the pregnant patients (0.8 per cent) exhibited enlargement which was ulcerated and well circumscribed. These four lesions were given a clinical diagnosis of pyogenic granuloma of the gingiva or "pregnancy tumor". Patients with slight discrete swelling on their gingiva claimed that the swelling began with the onset of gestation.

Of the 233 non-pregnant women in the study none had pyogenic

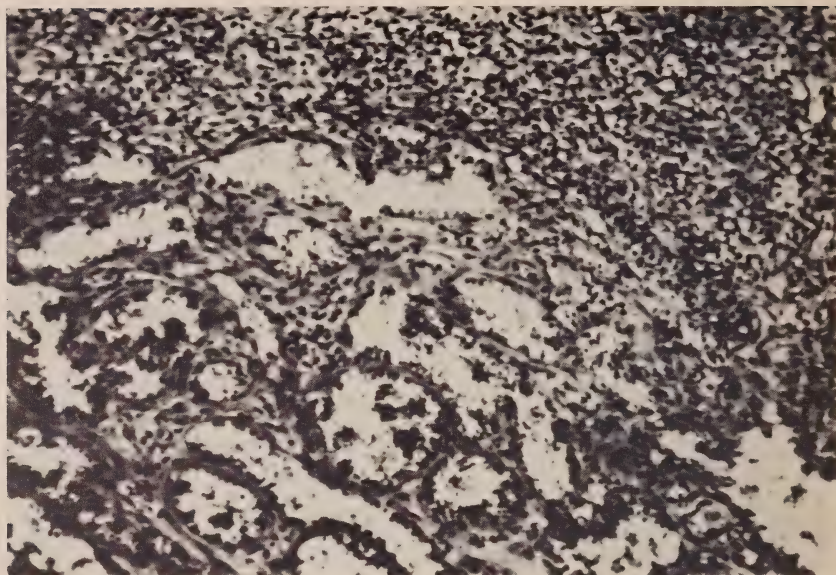


Figure 3: High power photomicrographs of pyogenic granuloma showing endothelial cells, blood vessels and inflammatory cells. (250X)

granuloma and 1.7 per cent had discrete enlargement of the interdental papillae.

The difference in prevalence of enlarged interdental papillae was statistically significant to the 95 per cent confidence level (Table II). Although the oral hygiene index (Table I) is higher in pregnant women than in non-pregnant, this difference was not statistically significant.

TABLE I
Periodontal and Oral Hygiene Indices
of 710 Patients

	Pregnant	Non-Pregnant
Number of Patients	477	233
Oral Hygiene Index	1.006	0.816
Standard Error = 0.19 ± 0.29		

It was found (Table III) that the difference between the oral hygiene indices of the pregnant women with enlarged interdental papillae and the pregnant women as a whole was not statistically significant.

DISCUSSION

In the patients with swelling of the interdental papilla and pyogenic granulomas there was an oral hygiene index higher than zero. This indicates that the accumulating plaque played some role in the development of the gingivae lesions. However, pregnant women showed more periodontal changes than the non-pregnant women did despite the fact that the oral hygiene was similar. This finding supports other investigators^{19,24} who stated that pregnancy gingivitis

TABLE II
The Presence of Swelling of Interdental Papillae in Pregnant and Non-Pregnant Women

	No. of Patients Examined	No. of Patients with swelling interdental Papillae	Percentage
Pregnant	477	42	9.6
Non-Pregnant	233	4	1.7

Standard Error = $.08 \pm 0.317$

and pregnancy tumor might be caused by a reactive process in which the tissue reaction was probably intensified by endocrine alteration occurring during pregnancy. Animal studies¹⁷ have shown that the gingival tissues show exaggerated reactions to traumatic stimuli during pregnancy.

The patients showing gingival enlargement stated that the changes began during pregnancy. This finding correlated or supported the finding of other investigators^{16, 19, 24} who stated that the concentration of sex hormones or the endocrine changes during pregnancy may have influenced the gingival tissues, anatomy and function and intensify the tissue reaction toward the local irritants. Tiilila²⁸ thought that "pregnancy tumor" arises on hormonal basis although some other factors are also involved in its etiology.

The prevalence of "pregnancy tumor" in this clinical study was 0.8 per cent which is nearly the same as found by Ziskin.²⁹

A statistical test (95 per cent confidence interval) was performed to find out the significance of the 0.8 per cent. It was found that there is an association between pyogenic granuloma and pregnancy; however, the association is weak and we must wait for more data before we make a final conclusion.

ACKNOWLEDGEMENTS

I would like to express my deep gratitude to Dr. Martin Lunin, Chairman of the Department of Oral Pathology for his help in preparing this article.

I also express my thanks to Ms. Paula Schachtel of the Department of Community Dentistry for her assistance in compiling the statistical figures of the test results.

TABLE III
Comparison of Oral Hygiene Indices

	Pregnant Women with swelling of inter- dental Papillae	All Pregnant Women
No. of Patients	42	477
Oral Hygiene Index	0.99	1.006

Standard Error = $.0065 \pm .4129$

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The Changing Faces of Dental Education: The Anatomy of the Clinical Dental Curriculum at the University of Maryland

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The Changing Faces of Dental Education: The Anatomy of the Clinical Dental Curriculum at the University of Maryland[†]

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The demand for health care services has increased steadily during the past two decades.¹ In part, this demand results from society's philosophy that "health care is a right, not a privilege". The impact of this philosophy on the health science professions is being felt in the increased demand for more physicians, dentists, and ancillary personnel.

It is apparent from the content of many publications and scientific meetings of the past ten years, that intense curricular revisions and modifications are occurring at many dental schools.² Education must be considered as an orderly process which changes the learner. This implies that the interactions between students and faculty must be designed to attain certain goals which would not have occurred without the educational process. Society, i.e. patients, professional organizations, students, faculty and the media, influence decisions regarding the goals that are desirable and the goals that should be

pursued. Achievement of these goals depends upon the selection of optimal teaching methods on the basis of hypotheses derived from learning and instructional theories. The correctness of instructional decisions must be assessed by evaluation.

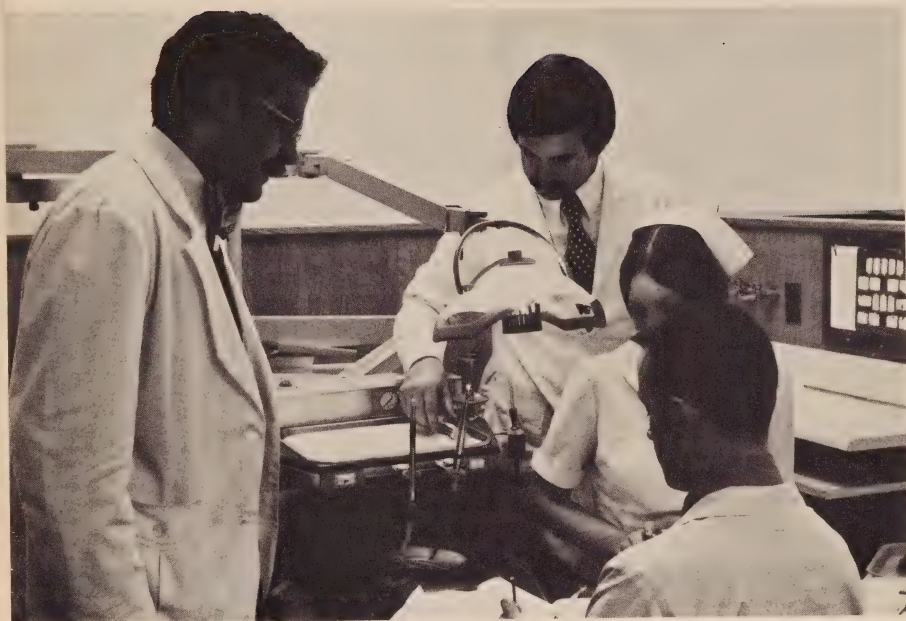
The present revolution in medical and dental education is often traced to the extensive curricular changes initiated at Western Reserve University in the early 1950's.³ At that institution, the traditional lockstep, departmentally-oriented curriculum was replaced by a more flexible educational program stressing interdisciplinary approaches for both the biomedical and clinical sciences. This movement has continued to spread very slowly for the past twenty years.

At present there are 57 dental schools in the United States.⁴ Five of these are new schools which accepted their first class in 1972. Many of them have unique programs. The trend today is to re-

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Team Teaching instruction is provided for comprehensive patient care in the clinics of the University of Maryland School of Dentistry.

duce the number of required student contact hours, to provide more free time in the curriculum for student self-study or the pursuit of electives, and to shorten the length of the curriculum. Bohannon et al⁵ have suggested that dental educators must disavow any educational program that is based primarily on time in residence and must admit that no student can learn everything a dentist must know within any period allocated for dental education.

Not all dental schools have made an effort to implement innovative curricula, but Allen⁴ points out six basic areas of emphasis for this change:

1. The outstanding student may be admitted to dental school earlier than before;
2. The dental curriculum will become more people-oriented and less technique-oriented;
3. Teaching methodology will become more self-instructional;
4. Behavioral objectives will commit the learning to a self-paced basis;
5. Students will learn more about dentistry earlier in their dental education, permitting greater elective flexibility and earlier specialization;

6. Students in dental school will have the opportunity to advance at their own individual rates.

THE CLINICAL DENTAL CURRICULUM AT THE UNIVERSITY OF MARYLAND

Since the principal objective in undergraduate dental education is the preparation of the student for general practice⁶, the clinical experience should allow the student opportunities not only to make use of previous learning, but also to develop further skills in rendering patient care. Toward this end, the University of Maryland School of Dentistry has initiated major curricular changes during the past eight years. The following new and often innovative programs represent several of the new curriculum modifications in the changing faces of dental education:

1. *Comprehensive Care* . . . Comprehensive or coordinated clinical patient care demands that the student will perform, where his ability permits, all dental services for the individual patient, from the preliminary workup to the completion of treatment, with emphasis on the proper chronological approach to patient management. This involves examination, diagnosis, treatment planning, case presentation, appointment control, prevention orientation, treatment performance, and patient recall.

Each student is required to introduce and maintain a sound prevention philosophy during all phases of his dental treatment. Emphasis is placed upon the student's concern for the total

oral health of the patient as it relates to the total systemic health. Not only is technical management of a variety of cases provided through comprehensive coordinated treatment, but clinical experience is also provided in dentist-patient relations.

2. *Community Service* . . . Annually, over 92,000 patient visits are recorded at the School of Dentistry, including almost 5,000 annual visits for the relief of pain and other dental emergencies. As the largest single provider of community dental care in the State of Maryland, the community service contribution is reflected in the provision of a facility for the delivery of services to those admitted. Maintaining an open admission policy for all who apply, once a patient is accepted for comprehensive treatment, he should be:
 - a. promptly appointed by the student for definite appointments;
 - b. oriented in prevention;
 - c. provided the best treatment plan, according to *his* needs;
 - d. provided systematic progress toward case completion;
 - e. provided continuing maintenance, preventive measures, and follow-up care.

No longer should a patient be accepted for individual services or manikin treatment, but patient education must be provid-

ed to permit acceptance of care on a total health basis.

3. *Computerized Data Retrieval...* Data bases are maintained at the School of Dentistry for not only the patient's, but the student's profile as well. All new patients are first registered, where the biographical information, including the past medical and dental histories, is computerized for information retrieval. Each student initiates his clinical care experience early in the second year. As each new patient is assigned to him, a record of the projected dental care is recorded on the student's individual computer printout. As treatment procedures are completed, a comprehensive profile is developed for the remaining clinical years of each student's educational experience. Integrated with this data base are the grade program and special assignments printouts.

4. *Special Programs...* In the development of the clinical curriculum at Maryland, the following special programs permit the student to expand his basic knowledge of dental practice:

- a. *Conjoint Science...* An integrated, interdepartmental, four-year program coordinating basic, applied and clinical sciences.
- b. *Biomedicine...* Coordinated integration of Oral Pathology, General Pathology, Internal Medicine, Physical Diagnosis, Oral Diagnosis, and Dental Radiology into one overall educational experience.

- c. *Independent Learning Center...* A continuously operating self-instructional learning center where independent student activity permits the introduction of new modular learning units and the self-paced reinforcement of previously presented material.
- d. *TEAM Program...* Through a pilot training program, advanced clinical students obtain experience in practice mechanics through participation in the expanded duty patient clinic.
- e. *Accelerated Professional Training...* Previously selected students may participate in a pilot program directed toward accelerated professional training in less than the conventional four-year program.
- f. *Special Patient Clinic...* Assignment to this clinic presents an opportunity for the advanced clinical student to obtain experience in the management and treatment of the special or handicapped patient. One of the few such facilities at any dental school in the United States, patients who present with chronic medical disorders which resist traditional dental therapy, may receive elective dental care on a regular basis.
- g. *Senior Clerkship Program...* On an elective basis, qualified Seniors may devote up to fifty percent of their last school year in a dental discipline of their choice.

- h. *Dental Externship Program* . . . This program, awaiting approval by the Maryland House of Delegates, will allow selected fourth year students to devote eight weeks of field study on location in the office of a practicing field instructor dentist in the State of Maryland. Not only will the Extern provide dental care in that community, but he will obtain valuable experience in practice dynamics at the private sector level.
- i. *Community Dentistry Enrichment* . . . All students participate at one of several levels in the four-year development of an understanding of the dental care delivery system at the community level.

Additional programs in Continuing Education, Post-Graduate Education, and Dental Hygiene provide the student, the patient, and the community with broader educational experiences. An Oral Medicine Consultation service provides

dental practitioners and patients in Maryland with a University-based referral center for case evaluation and consultation.

SUMMARY

Dental education is responding to the challenge of patient care through new and often innovative curriculum changes. Several of the programs at the University of Maryland, which are the result of this challenge, have been presented. The humanistic approach to patient care is being emphasized while allowing the student maximum flexibility for educational enrichment. Future trends and demands will place further burdens on dental educators to develop educational programs which permit this flexibility. Dental licensing bodies must recognize these changes in educational philosophy, and must encourage all practitioners to continue to enrich their educational experience on a regular and voluntary basis. The University of Maryland School of Dentistry looks forward to the continued improvement in the delivery of dental health care.

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Letter to the Editor

Why Forensic Denistry!

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Forensic Dentistry, that branch of dentistry which deals with the relation and application of dental facts to legal problems, is relatively new. Even though teeth have been used as a means of identification since the time of Nero, the first comprehensive textbook in the English language, by Gustafson, was not published until 1966. It is only during these past eight years that Forensic Dentistry has begun to emerge as a recognized science.

By far the greatest number of cases for which the forensic dentist, or odontologist, will be consulted are in the area of identification of unknown bodies or remains by means of dental examination and comparison. This can either be a single body, or a mass disaster such as an aircraft accident. The importance to families and friends, police and insurance companies of obtaining an accurate and positive identification of an unknown individual is self-evident.

Since the teeth are the most indestructible of all animal tissues, they and the metallic fillings contained within are frequently the only structures remaining and identifiable following a holocaust, or remains which have become skeletalized following prolonged post mortem periods prior to discovery. In these instances fingerprints or visual inspection will be of no value, as none remain to examine. By examination of specific dental characteristics, such as tooth shapes and numbers, as well as the number, type and location of dental restorations, an accurate recording can be made of an individual's oral cavity. Other factors, such as congenital bite patterns or shapes of facial features, when present, can also aid in identification. By analysis of dental and oral findings, the age, sex, race, socio-economic level and habits, such as smoking and some types of drug usage, can often be determined. These in themselves, however, will not allow for the

positive identification of an individual unless there are accurate previous dental records available for comparison. Therefore it is essential that every dental practitioner maintain detailed, accurate records on all of his patients, since it can never be known when one of those records will be the only link to the establishment of a positive identification of a loved one — or to a murder.

More recently the analysis of bite marks left in hard substances, food stuffs and human skin have come under scrutiny as a means of identification, or exclusion, of an individual suspected of a crime. Certain crimes, such as the battered child and crimes of passion often leave the victim marked by the teeth of the assailant. Often the attacker himself will be bitten by the victim as a defense maneuver. Careful analysis and measurement of the marks and comparison with models of the teeth and bite of the alleged suspect have now been ad-

mitted as evidence in U.S. Courts. This phase of the art or science of Forensic Dentistry is still the subject of much controversy.

There are few places today where a dentist can get a thorough knowledge of the field of Forensic Dentistry. The graduate can get training through recognized continuing education courses at dental schools and at the Armed Forces Institute of Pathology. Some dental schools are now teaching Forensic Dentistry to dental students as part of their undergraduate course in dentistry.

Every graduate dentist should be able, by utilizing the knowledge gained in dental school, to accurately examine dental remains, record the findings and compare these to previous dental records to establish the identity of the unknown individual. He should be able to — and quite often and unexpectedly is called upon to — take this responsibility.

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